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Study on fabrication and application of unsaturated polyester composite materials reinforced with Eucalyptus/Melaleuca wood shavings

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ABSTRACT

A novel strategy combining Eucalyptus/Melaleuca shavings and unsaturated polyester resin was used to fabricate composite materials with outstanding aesthetics and good mechanical strength by using a hot press and manual method. The composite material produced has a flexural strength of 49.15/49.32 MPa, tensile strength of 22.38/23.83 MPa, and impact strength of 4.89/4.76 kJ.m^{-2} under optimal processing conditions of 120°C, 3 minutes, 150 kg.cm^{-2} pressure, and 40% shaving content by volume. Treating the shavings with a 2% NaOH solution improves the interface between the shavings and resin, increasing the flexural strength of the Eucalyptus/Melaleuca shavings composite material to 77.06/77.12 MPa. Some of the manufactured products, such as table and chair tops, plant pots, desk cabinets, and wall shelves, highlight the possibilities of employing scrap shavings to create new materials for use in municipal and industrial applications.

1. INTRODUCTION

Shavings are solid wood waste/by-products produced during the carving, statue-making, or processing of wood products. Previously, shavings were exclusively used as bedding for livestock pens, firewood, fertilizer, or mushroom cultivation. Many industries now recycle shavings into particleboards by combining shavings, wood dust, and sawdust with glue and pressing at high temperatures (Spear et al., 2015; Basalp et al., 2020; Zhang et al., 2022). This product costs less than solid wood and other forms of plywood. Currently, some experiments are being conducted to improve the quality of plywood. Giang et al. (2017) investigated the usage of block-pressed bamboo boards as materials. During the high-frequency heat pressing operation, the bamboo block plywood's internal temperature change was detected, and the analysis and trend of temperature change inside the board according to humidity were provided. The results showed that the temperature of the board increased significantly as the humidity of the raw bamboo bar increased from 6 to 18%, with a glue content of 300 g.m^{-2}. The study provided the following parameters for high-frequency heat pressing of bamboo block plywood: adhesive content 300 g.m^{-2}, bamboo bar humidity 12%, and a high-frequency heat pressing period of 10 minutes. Trinh et al. (2023) investigated the effects of temperature and pressing time on the primary mechanical and physical properties of plywood. Plywood was made by peeling Acacia Auriculiformis wood and covering it with 120 g.m^{-2} cashew nut shell oil adhesive. The pressing mode options include three pressing temperatures: 110°C, 120ºC, and 125ºC, as well as three pressing times: 13, 15, and 17 minutes. The fixed press pressure is 1.1 MPa. The pressing mode yielded the optimum mechanical and physical qualities. The pressing temperature is 125ºC, the pressing period is 15 minutes, and the pressing pressure is 1.1 MPa. Luong et al. (2024) investigated technologies for using agricultural byproducts like coconut fiber as raw materials in the artificial board manufacturing sector. The results were three-layer particle board products created from three types of coconut fiber waste that met the requirements of particle board as raw materials for furniture manufacturing when utilized in dry mode, as measured by two quality assessment criteria: swelling and static bending modulus of elasticity. Yimer et al. (2023) explore the influence of specimen relative height location and bamboo layering on the fabrication of composite flexural material from Eucalyptus Globules and Oxytenanthera Abyssinica bamboo for floor deck construction. Furthermore, flexural enhancement was investigated by laminating bamboo beneath eucalyptus, which has a high tensile stress resistance, with unsaturated polyester resin as the bonding medium. The test findings revealed that single and double-layer bamboo laminated eucalyptus in the bottom part showed an increase in flexural strength of 26.5% and 33.06%, respectively, and that the bottom portion strength had enhanced due to the addition of bamboo. Adding a bamboo lamination to the middle portion of the eucalyptus resulted in a 20.31% increase for the single layer and a -41.79% loss for double layer strength compared to the non-laminated middle part eucalyptus (Yimer et al., 2023).

Zhang et al. (2023) increased the variety of thermoplastic plywood, lowered the hot-press temperature, and reduced energy use. A unique wood-plastic composite was created using ethylene-vinyl acetate (EVA) film as a wood adhesive. Plywood is made using hot and secondary press techniques. The impacts of hot-press and secondary press operations at various temperatures on the physical-mechanical properties of EVA plywood (tensile shear strength, 24-hour water absorption, and immersion peel performance) were investigated. The results reveal that the qualities of the plywood produced with the EVA film as an adhesive can meet the type III plywood standard. The optimal hot-press duration was 1 min/mm, the hot-press temperature was 110–120ºC, the hot-press pressure was 1 MPa, the dosage film was 163 g.m^{-2}, the secondary press time was 5 minutes, the secondary press pressure was 0.5 MPa, and the secondary press temperature was 25ºC. EVA plywood can be utilized indoors.

However, the particle board processing requires significant initial investment in equipment while producing goods of relatively good mechanical quality, and relatively high moisture absorption capacity (Hernández et al., 2020; Mitchual et al., 2020; Adeniran et al., 2021). To increase the value of wood shavings, a new material combining shavings and thermosetting polyester resin (UPE) is proposed for investigation using a simple manual process. The project's major goal is to effectively create a material combining wood chips and thermosetting polyester resin while maintaining high aesthetics, mechanical characteristics, and water resistance. From there, particular test goods with commercial potential are created from the previously examined materials. This research promises to produce a new material with great aesthetics (such as smoothness, diversity in patterns and colors), strong mechanical qualities, particularly good water resistance, and the ability to process interior products entirely in place of traditional wood.

2. MATERIALS AND METHOD

2.1. Materials

Eucalyptus shavings were collected from a wood processing workshop in Thot Not district, Can Tho city, Vietnam. melaleuca shavings were collected from a wood workshop in Thoi Binh district, Ca Mau city, Vietnam. eucalyptus/melaleuca shavings were pre-treated (such as by removing impurities, dust, sawdust, etc.).

Experimental chemicals included unsaturated polyester resin (UPE, R2803, styrene content 30 - 35%, 0.5% cobalt octoate, viscosity 400 - 500 cPs, density of resin is 1.11 - 1.13 g.cm^{-3}, Taiwan), curing agent methyl ethyl ketone peroxide (MEKP, peroxide content 33%, oxygen 8 - 9%, phthalate 50%, China), sodium hydroxide (NaOH, > 96%, Xilong, China).

2.2. Processing of eucalyptus/melaleuca wood shaving mats

For experimentation, two types of wood shavings (eucalyptus wood shavings and melaleuca wood shavings) were used to compare. The wood shaving mats were prepared in four steps shown in Figure 1. First, the collected wood shavings were pre-treated to remove contaminants. The wood shavings were then treated with a 1 to 4% NaOH solution for 2-8 hours (Shulga et al., 2023). The treated wood shavings were washed to pH 7 and dried at 50ºC for 24 hours. Next, the wood shavings were evenly distributed in the mold to prepare for the hot pressing stage. During this stage, the fabrication temperature (the experimental range is 120 and 130ºC), fabrication time (the experimental range is 2 and 3 minutes), and fabrication pressure (the experimental range is 50, 100, and 150 kg.cm^{-2}) were critical in determining the optimal conditions for surface density and ordered bonding, resulting in wood shavings with flat surfaces and the best mats color.

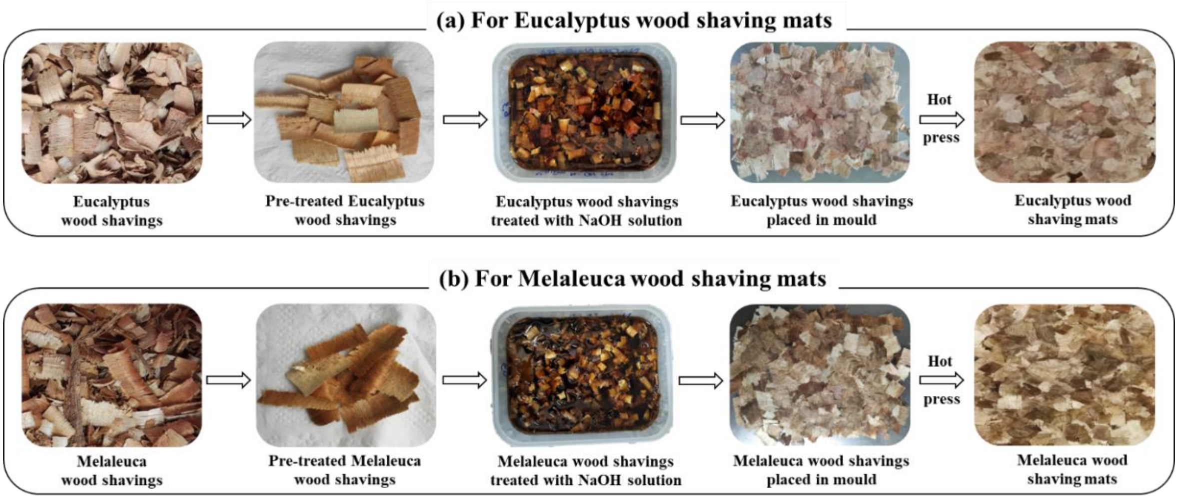

Figure 1. Eucalyptus/melaleuca wood shaving mat processing

2.3. Processing of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shavings

The parameters of the wood shaving composite materials fabrication process conclude wood shaving mat processing conditions (pressing temperature, time, and pressure), wood shaving content (investigated at levels of 10, 20, 30, 40, 50, and 60% by volume), and NaOH concentration (investigated at levels of 1, 2, 3, and 4%). The above-mentioned composite samples to be studied were made using the hand-lay-up approach described in Figure 2. The mold has dimensions of 16 x 13 x 0.3 cm in length, width, and height and is placed on a 2 cm thick tempered glass plate. To thinly coat the sample's contact surfaces, mold release wax was utilized. Next, unsaturated polyester resin (UPE) was created by stirring with 1% methyl ethyl ketone peroxide (MEKP) initiator. 20% of the UPE resin mixture containing the curing agent was equally distributed throughout the mold. After 10 minutes, the mold proceeded to fill with 20% of the mass of the curing agent-containing UPE resin mixture. The preform sheet was then evenly coated with 40% UPE resin containing curing agent and pre-pressed into the mold to remove air bubbles and improve the contact between the preform sheet and resin. Finally, the remaining UPE resin, including curing agent, was added to the mold and pressed at ambient temperature for 12 hours while maintaining a pressure of 10 MPa. Following mold release, the composite material in sheet form was cut to a standard size to determine mechanical strength, such as tensile, flexural, and impact strength.

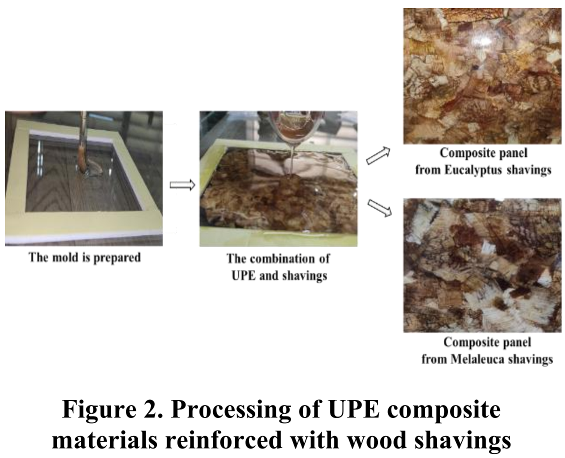

Figure 2. Processing of UPE composite materials reinforced with wood shavings

2.4. Testing the mechanical properties of materials

The composite specimens' tensile strength, flexural strength, and impact strength were measured using the American Society of Testing and Materials standards ASTM D638-03 (length x width = 165 x 10 mm), ASTM D790M-84 (length x width = 45 x 15 mm), and ASTM 256 (length x width = 127 x 12.7 mm, Charpy hammer type) with 5 repetitions (Nurul et al., 2019; Kibet et al., 2022; Marta et al., 2022).

2.5. Processing products from composite materials reinforced with eucalyptus/melaleuca wood shavings

Applied items (such as table and chair sets, desk shelves, bookshelves, flower baskets, wall shelves, and soundproof walls) created from composite materials combining wood shavings and UPE resin are also processed manually based on the optimal parameters as described above. Figure 3 depicts the manufacturing process of chairs (representing the aforementioned products) made from composite materials with eucalyptus wood shavings. Three basic stages are taken while processing a chair made of composite materials reinforced with eucalyptus wood shavings. Step 1 is to prepare wood shaving mats, which includes putting wood shavings into the mold after weighing the exact ratio and then pressing them in the hot press under the optimal circumstances surveyed to produce complete wood shaving mats. Step 2 involves preparing UPE resin by adding the required amount of MEKP curing agent, stirring, and vacuuming. Step 3 involves placing resin and fiber into the mold and then attaching the composite blank to the frame to create a full chair. A fiberglass sheet is placed on the chair seat during processing to increase the mechanical strength of the product.

Figure 3. Processing chair from composite materials reinforced with eucalyptus wood shavings

3. RESULTS AND DISCUSSION

3.1. The results of parameters influencing wood shaving mat fabrication

3.1.1. The effects of fabrication pressure

The processing of wood shaving sheets was investigated at pressure levels of 50, 100, and 150 kg.cm^{-2} with a constant temperature of 120^{o}C and a pressing time of 3 minutes for each experiment. The results in Figure 4 showed that when squeezed at a pressure of 50 kg.cm^{-2}, the wood shaving sheets remained loose and unbonded, possibly because the pressure was insufficient to act on the wood shavings' surface. At a pressure of 50 kg.cm^{-2}, the link between the wood shavings remains loose, therefore the shaving mat has not yet been formed. When the pressure is increased to 100 kg.cm^{-2}, the wood shavings bond more strongly than when crushed at 50 kg.cm^{-2}. When the pressure increases to 150 kg.cm^{-2}, the wood shavings bond more securely, resulting in a better-shaped shaving mat. As a result, wood shavings treated at a pressure of 150 kg.cm^{-2} were used to create the wood shaving composite product.

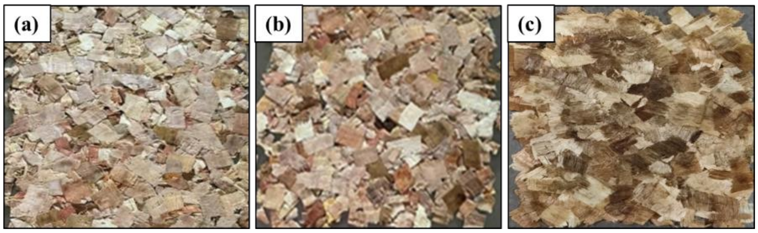

Figure 4. Wood shaving mats at different pressure: (a) 50 kg.cm^{-2}, (b) 100 kg.cm^{-2}, and (c) 150 kg.cm^{-2}

3.1.2. The effects of fabrication temperature and time

Processing eucalyptus/melaleuca wood shavings at different temperatures of 120 and 130^{o}C respectively was adjusted to a hot press with a fixed pressing pressure of 150 kg.cm^{-2}. The wood shavings were fixed and placed in the pressing mold. The mold containing the wood shavings was fixed on the hot press and the pressing time was set to 2 and 3 minutes for each experiment (Figure 5). The surface shape and color of the wood shavings, as well as their bonding capabilities, were studied under various temperature settings.

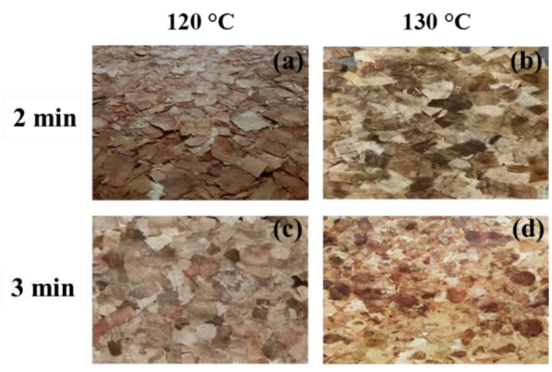

Figure 5. Wood shaving mats at different pressing temperature and time: (a) 120^{o}C and 2 min, (b) 130^{o}C and 2 min, (c) 120^{o}C and 3 min, (d) 130^{o}C and 3 min

At a temperature of 120^{o}C and a pressing time of 2 minutes, the wood shavings only adhere to each other relatively, resulting in an uneven surface of the wood shavings that is easily broken into pieces, negatively impacting product processing and reducing the mechanical properties of the composite product. The reason may be that the lignin in the wood shavings is not flexible enough to bond the pieces together. When the temperature is maintained at 120^{o}C and the pressing duration is raised to 3 minutes, the chipboard has a flatter surface, a generally consistent thickness due to the chipboard's tight bonding, and no crumbling. This could be because the lignin in the chipboard reaches the softening temperature, causing the fragments to join together. As a result, the chipboard is well-shaped and evenly distributed, with the colour remaining practically intact. The tight linkage of the shavings and good contact between the shavings improve the mechanical qualities of the product and allow the processing of composite goods derived from the shavings. When the pressing temperature is raised to 130^{o}C, the surface of the shavings darkens in both survey times (2 and 3 minutes). Furthermore, shavings undergo form alterations, such as warping, as a result of shrinking in response to warming. This reduces the product's visual attractiveness while also affecting the mechanical qualities of the composite. As a result, the temperature of 120^{o}C and the period of 3 minutes are appropriate for processing shavings to reinforce the composite material made of UPE plastic.

3.2. The results of parameters influencing on mechanical strength of unsaturated polyester composite materials strengthened with eucalyptus/melaleuca wood shavings

3.2.1. Effect of wood shaving mat processing temperature on mechanical strength of unsaturated polyester composite materials

Composite specimens were evaluated at temperatures of 120 and 130ºC. The constant factors were 150 kg.cm^{-2} and 3 minutes. Impact strength of test specimens prepared in accordance with ASTM D256 using a Charpy impact hammer. Figure 6 depicts the effects of the processing temperature of eucalyptus/melaleuca wood shavings on the mechanical strength (such as tensile, flexural, and impact strength) of the composite material. In summary, the results demonstrate that the tensile strength of both composite samples made from eucalyptus chips and Melaleuca chips attained its maximum value at chip processing temperatures ranging from 120 to 130ºC. At each temperature level, the tensile strength of Melaleuca chips was greater than that of eucalyptus chips, but the difference was not significant since the sizes of the eucalyptus and melaleuca chips were comparable. The wood shavings have relatively short dimensions compared to natural fibres, hence the tensile strength of the composite samples is low. Flexural strength values for eucalyptus wood shaving and Melaleuca wood shaving are similar across 110-130ºC, but higher at 120ºC (~38.81 MPa and ~38.48 MPa, respectively). This could be because the temperature of 120ºC is a suitable condition for the softening process of lignin, which helps to link more tightly, resulting in a sample with greater flexural strength than at 110ºC. Overheating may cause not just lignin but also a portion of cellulose to sear or degrade, resulting in a loss in flexural mechanical characteristics when compared to the processing temperature of 120ºC. The impact strength measurement results of the test samples did not differ significantly. At 120ºC, eucalyptus (~5.69 KJ.m^{-2}) and melaleuca (~5.82 KJ.m^{-2}) had the highest impact strength. This is due to the lignin content in the blastocyst reaching the ideal temperature for lignin bonding, which helps bond the wood shaving together and improves the mechanical properties of the blastocyst sheet (Nurul et al., 2019; Reinprecht et al., 2019). Therefore, composite samples made from eucalyptus/melaleuca chipboard processed at 120ºC have the highest mechanical strength; this is the temperature used in the subsequent investigations.

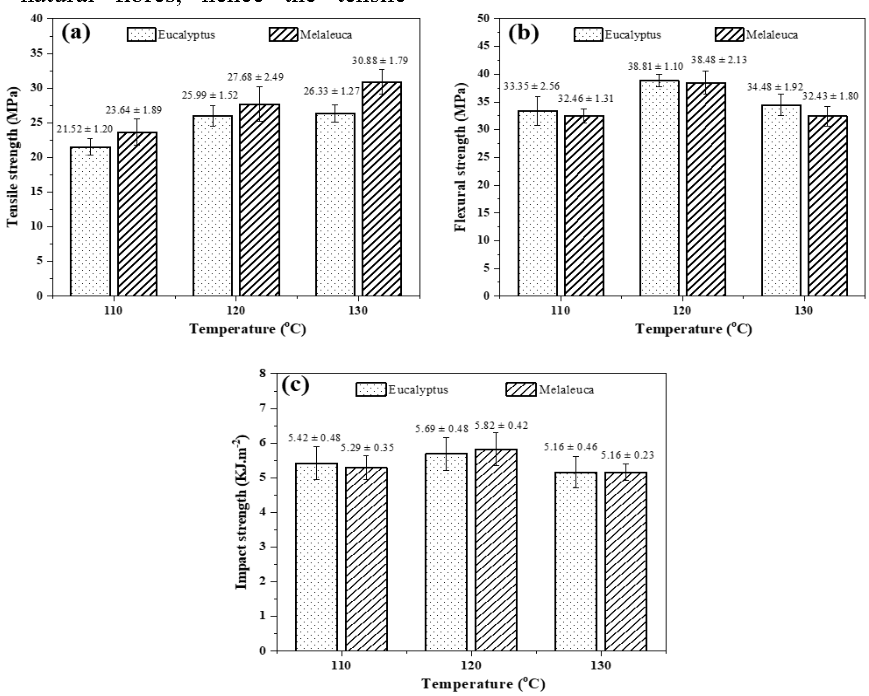

Figure 6. Mechanical strength results: (a) tensile strength, (b) flexural strength, and (c) impact strength of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shaving mats at different pressing temperatures

3.2.2. Effect of wood shaving mat processing pressure on mechanical strength of unsaturated polyester composite materials

The composite samples were processed under planed sheet conditions with pressures of 50, 100, and 150 kg.cm^{-2}, respectively. The fixed factors for planned sheet processing were a temperature of 120^{o}C and a period of three minutes. Figure 7 depicts the results of tensile, bending, and impact strength tests on test specimens made from planed sheets processed at various pressures. In general, the tensile strength of the eucalyptus/melaleuca composite samples did not differ significantly between chipboard processing pressures. The cause is that the chipboard is small, has low tensile strength, and is easily separated due to sample elongation, which easily breaks the links between the chipboard. Specifically, with chipboard treated at a pressure of 50 kg.cm^{-2}, the bond between the chipboard is weak and readily broken, producing challenges in the modeling process. Processing the plank sheet at a pressure of 100 kg.cm^{-2} results in a relatively higher tensile strength than at a pressure of 50 kg.cm^{-2} because the plank sheet is relatively tight; however, the pressure is insufficient to make the surface of the plank sheet flat, preventing the interface between the base resin and the plank. The best tensile strength is obtained when pressing at a pressure of 150 kg.cm^{-2} because pressing at this pressure gives the plank sheet a flat surface and tighter connections between the planks, increasing the tensile mechanical properties of both the plank sheet and the samples. Composite samples containing both Eucalyptus and Melaleuca boards show no significant difference in bending strength (Al-Mosawi et al., 2014). At a processing pressure of 150 kg.cm^{-2}, both eucalyptus/melaleuca shavings had the highest bending strength. This could be attributed to the fact that at a pressure of 150 kg.cm^{-2}, the shavings had a tighter bond, and the surface of the shavings after processing was flat, which helped to improve the contact surface between the base resin and the shavings when compared to the processing conditions of 50 and 100 kg.cm^{-2}. Similar to the results of tensile and bending mechanical properties, the impact strength of the pressed sample at a pressure of 150 kg.cm^{-2} for eucalyptus/melaleuca shavings was the greatest due to the highest impact kinetic energy value. The reason is that, at the pressing pressure, the shaving mat has better bonding between the shaving layers, and the flat shaving surface improves the bonding contact between the shaving sheet and the base plastic, boosting impact resistance. The wood shaving sheet provides rather strong impact resistance when processed at pressures of 50 and 100 kg.cm^{-2}; however, because the pressing under these conditions is not optimal, the shavings do not have a tight connection with each other, particularly at 50 kg.cm^{-2}, hurting the material processing process.

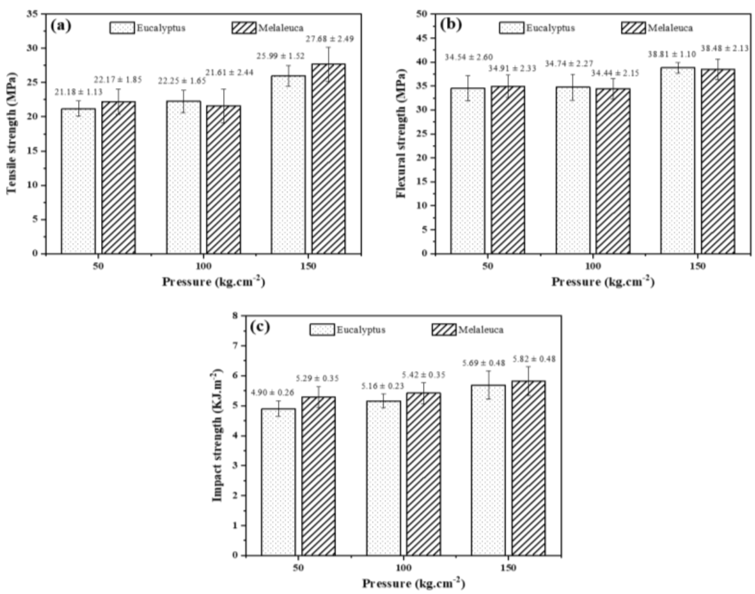

Figure 7. Mechanical strength results: (a) tensile strength, (b) flexural strength, and (c) impact strength of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shaving mats at different pressure

3.2.3. Effect of wood shaving content on mechanical strength of unsaturated polyester composite materials

The composite material samples were processed with various wood shavings contents, including 10, 20, 30, 40, 50, and 60% by volume. The best parameters were set as wood shavings processing the temperature of 120ºC, time of 3 minutes, and pressing pressure of 150 kg.cm^{-2}. Figure 8 depicts the mechanical characteristics of samples with varied amounts of wood shavings. Tensile strength follows the same pattern as impact strength for each treatment (Figures 8a and 8c). Both eucalyptus and melaleuca test specimens showed an increase in tensile and impact strength with increasing wood shaving percentage, peaking at 20%. However, when the wood shaving concentration exceeded 30%, the specimens tended to decline dramatically. The reason for this is that as the wood shaving content increases in volume percentage, the resin content in the specimen decreases, resulting in insufficient resin to bond with the wood shavings, weakening the material and causing delamination between the wood shavings and the resin. Figure 8b demonstrates that the flexural strength values of the samples follow the same trend as the tensile/impact strength. Flexural strength values for eucalyptus wood shaving progressively grew from ~25.73 MPa to ~49.15 MPa as wood shaving content increased from 10% to 40%, while Melaleuca wood shaving steadily climbed from ~27.85 MPa to ~49.32 MPa. This flexural strength result is higher than the flexural strength standard of TCVN 7754:2007 (13 MPa with plate thickness 3-6 mm). When wood shaving concentration reaches 50-60%, the flexural strength of composite samples from both types of wood shaving decreases significantly. The issue could be insufficient unsaturated polyester resin to evenly penetrate and connect the wood shaving. Briefly, select a wood shaving content of 30% or 40%, depending on the intended product application.

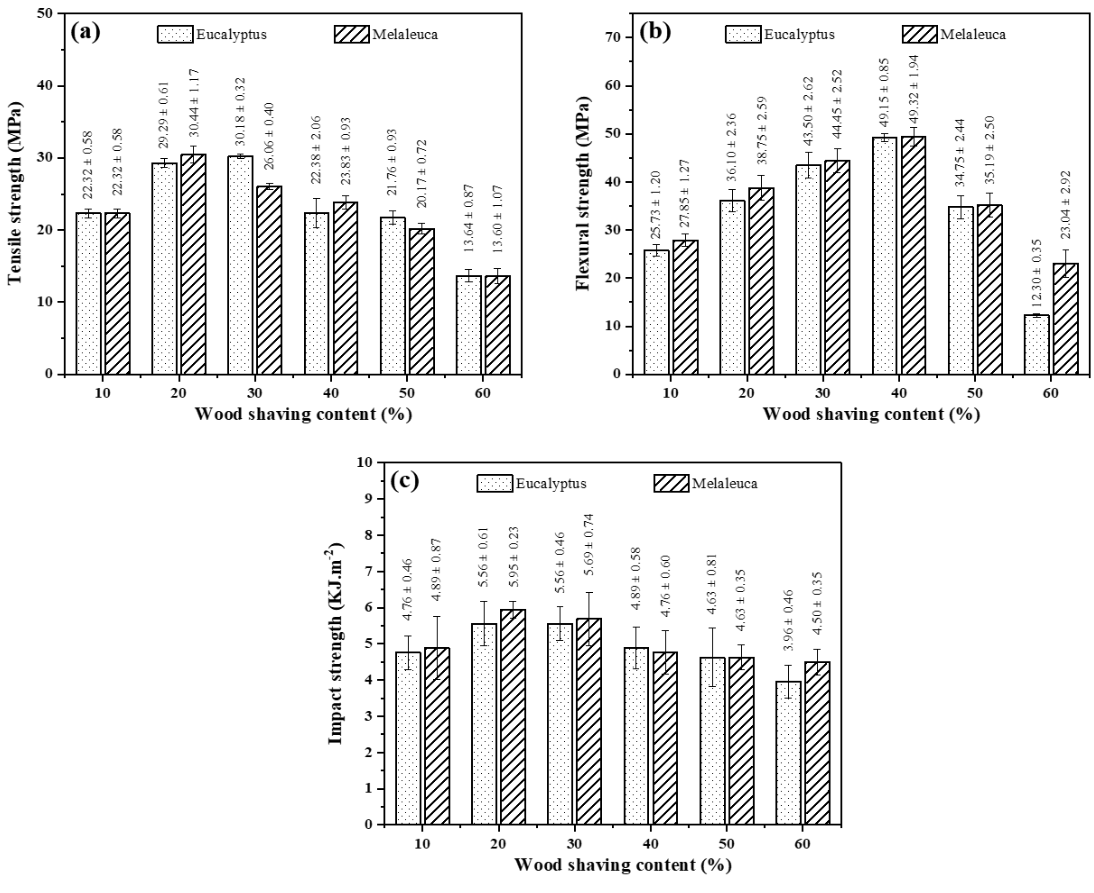

Figure 8. Mechanical strength results: (a) tensile strength, (b) flexural strength, and (c) impact strength of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shaving mats at different wood shaving contents

3.2.4. Effect of sodium hydroxide concentration on mechanical strength of unsaturated polyester composite materials

Eucalyptus/melaleuca chips were soaked in NaOH concentrations of 1, 2, 3, and 4% for 4 hours (Li et al., 2007). After soaking, the chips were rinsed with water and dried before being processed into a chipboard at 120°C for 3 minutes and 150 $kg.cm^{-2}$ pressure. The chipboard content used was 40% of the material's volume. The samples were cut and tested for tensile, bending, and impact strength per the standard. Figure 9 shows the results of testing the mechanical strength of test samples with chipboard treated at various NaOH concentrations. In general, when the wood shavings were treated with NaOH, the tensile strength grew, but the difference was not significant. The composite sample made from eucalyptus wood shaving had the highest tensile strength at a concentration of 1% NaOH, indicating that at 1%, the lignin content and other substances were lost but less than at concentrations of 2, 3, and 4%, so at 1%, the tensile strength was the highest when the wood shaving content in the sample was 40%. Similar to the composite sample from Eucalyptus wood shaving, the composite sample from Melaleuca wood shaving exhibited the best tensile strength result at a concentration of 1% NaOH; nevertheless, the tensile strength of the sample tended to drop progressively at concentrations more than 2, 3, and 4%. In general, tensile strength increased with treatment, peaking at 1% NaOH concentration compared to the untreated sample above. However, at concentrations of 2%, 3%, and 4%, the sample's tensile strength declined somewhat, with the lowest value at 4% NaOH for both types of wood shaving. This is due in part to the destruction of a major portion of the wood shavings' lignin, hemicellulose, wax, and other components. These chemicals acted as adhesives between the cellulose fibers in the wood shaving, therefore their removal diminishes the bonding between the cellulose fibers, lowering the tensile strength of the wood shaving sheet and influencing the tensile strength of the wood shaving composite sample (Shulga et al., 2023). Therefore, immersing the wood shaving in a greater concentration of NaOH will reduce the tensile strength of the sample.

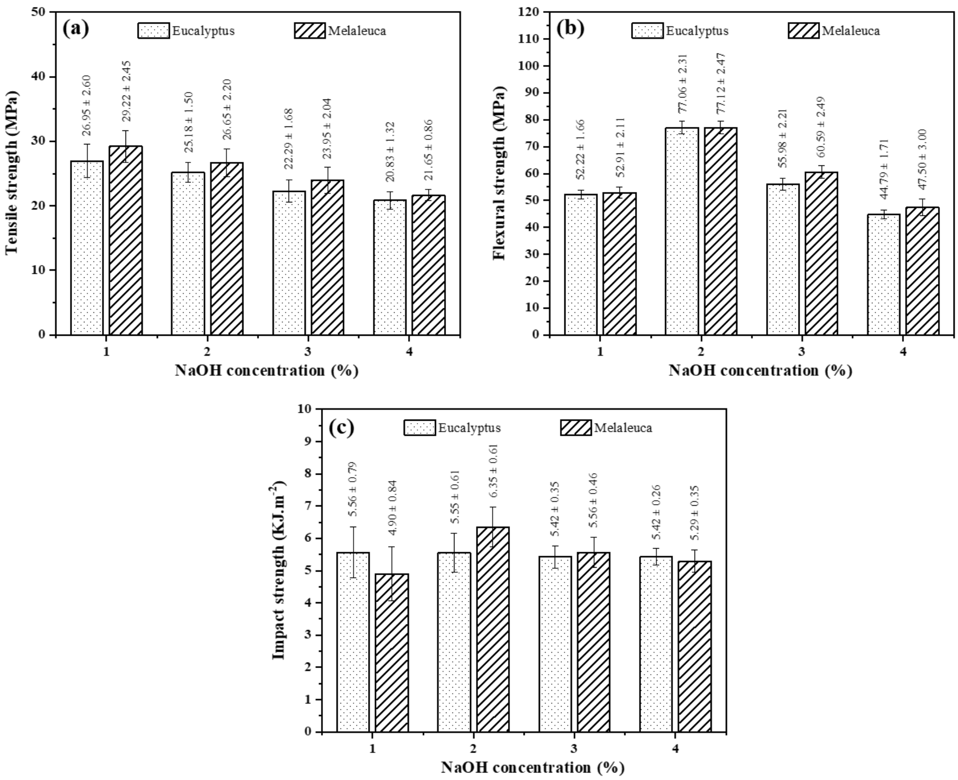

Figure 9. Mechanical strength results: (a) tensile strength, (b) flexural strength, and (c) impact strength of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shaving mats treated at different NaOH concentration

When composite materials were treated with NaOH, their flexural mechanical capabilities improved dramatically in comparison to when the wood shaving was not treated. The favourable improvement in flexural mechanical properties was caused by the partial release of hemicellulose and lignin from the structure of wood shaving, with both shavings having significantly higher cellulose content. Furthermore, treating wood shaving with NaOH solution softens them, removes the majority of the outer layer of acne, and increases the concentration of beneficial compounds for the wood shaving's mechanical qualities. NaOH treatment significantly enhanced eucalyptus wood shaving by ~57% and Melaleuca wood shaving by ~74%. Thus, at a concentration of 2% NaOH, the composite material's flexural strength was best with eucalyptus/melaleuca wood shaving. In general, composite samples with treated chips exhibit similar impact resistance to untreated chips with NaOH. The reason is that, while eucalyptus/melaleuca chips have been treated to improve and tighten the interface between the chip and the base resin, the base resin content remains relatively high, and as a thermosetting resin, the impact resistance does not change despite being treated, improving the mechanical properties of the chips. Composite materials with eucalyptus chips treated at a concentration of 2% had the highest impact on resistance, outperforming composite materials with eucalyptus chips. However, when the wood shavings were treated with NaOH concentrations ranging from 3 to 4%, the mechanical values of the composite materials from both types of shavings declined because the lignin content was reduced, limiting the connection of cellulose fibers in the shavings.

3.3. Application product results

The products of unsaturated polyester composite materials reinforced with eucalyptus/melaleuca wood shavings were processed using the above-mentioned optimal parameters for the shavings (processing temperature of 120ºC, time of 3 minutes, and pressure of 150 kg.cm^{-2}) and composite materials from shavings (shavings content 40%, NaOH treatment solution 2%). Figure 10 depicts the obtained products such as table and chair sets (a), desk shelves (b), bookshelves (c), flower baskets (d), chairs (e), wall shelves (f), and soundproof walls (g).

Figure 10. Products from unsaturated polyester composite materials reinforced with Eucalyptus/Melaleuca wood shavings

4. CONCLUSION

Eucalyptus/Melaleuca wood shavings were successfully processed under optimal conditions, which included a processing temperature of 120ºC, a time of 3 minutes, and a pressure of 150 kg.cm^{-2}. The results showed that the eucalyptus/melaleuca chipboards were strongly bonded together, the board's surface was level, the mold was simple to remove, and there were very few overheated spots. Manually fabricated composite materials, containing 40% wood shavings by volume, achieve flexural strengths of 49.15 and 49.32. The mechanical properties of composite materials created from eucalyptus/melaleuca shavings meet the technical standards specified in TCVN 7754:2007, making them suitable for the production of chair surfaces, table tops, and interior decoration. Furthermore, when compared to untreated eucalyptus/melaleuca wood shavings, treating them with a 2% NaOH solution improved the wood shavings surface, enhanced the composite material's flexural mechanical properties by about 56%, and increased the tensile and impact mechanical properties only slightly.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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