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Sustainable solutions: Tamarind Seed Kernel powder (TKP) adhesive as a green alternative for lignocellulosic composites

The majority of petroleum-based adhesives applied in the wood industry today, particularly formaldehyde-based adhesives. Their application trend is increasing due to their wide availability, superior bonding, durability, and resistance to heat and moisture. However, formaldehyde-based adhesives continuously release low molar mass hazardous carcinogenic chemicals, such as formaldehyde gas. In addition, the petroleum-derived adhesive industries have come up with bio-based adhesives including starch, protein, lignin-based adhesive that are more beneficial to the environment and human health in response to the increasing environmental issues. TKP is rich in xyloglycan starch molecules composed of (1-4)-β-D-glucan backbone substituted with side chains of α-D-xylopyranose and β-D-galactopyranosyl (1-2)-α-D-xylopyranose linked (1-6) to glucose residues. Industries have utilized the kernel powder as stabilizers, thickening agents, emulsifiers, dietary fibers, coatings, encapsulants, and controllers in crystallization activities but the chemical compositions of tamaring seed kernel powder ensure that this discarded material can be converted to a green adhesive for the composite industries. Thus, the study was focused on manufacturing and characterizing more environmentally friendly and sustainable alternative green adhesive from TKP to conventional adhesives, which are often made from petrochemicals and have negative impacts on the environment.

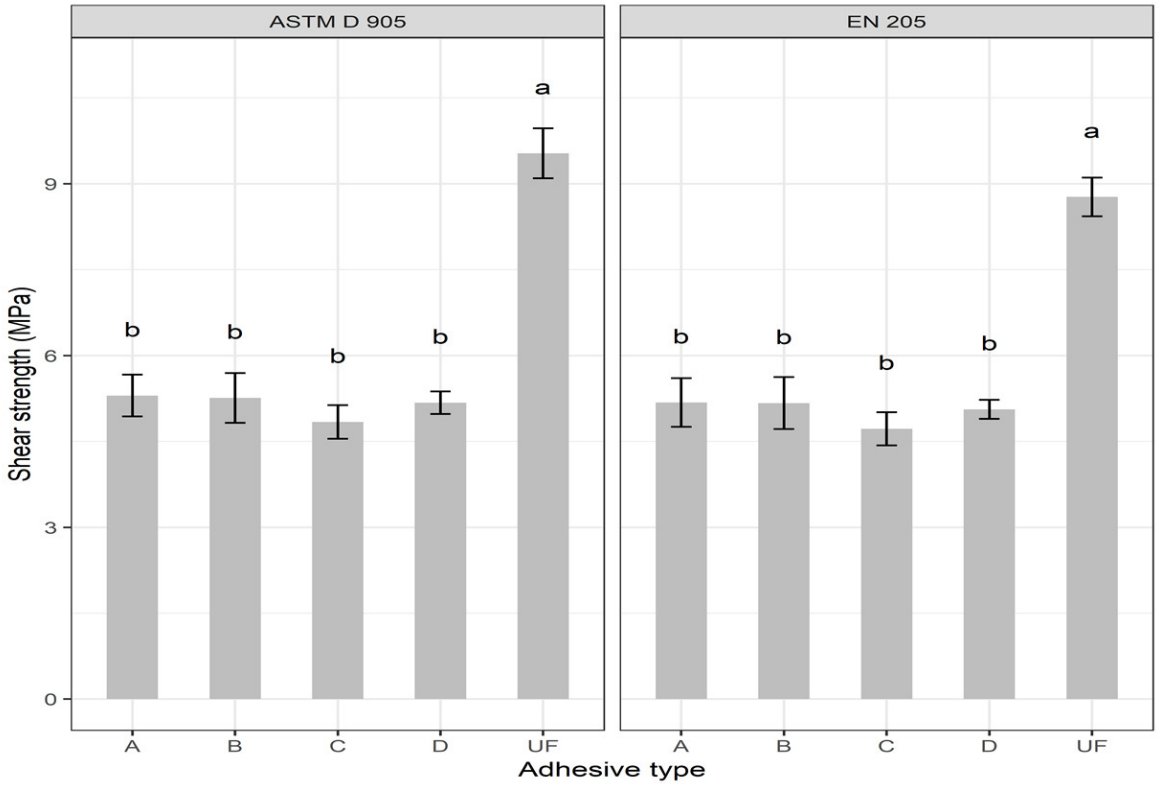

Fig. 1.

The idea of the research was based on finding a green, renewable and non-toxic adhesive and characterizing the adhesive after adding different chemicals or active compounds with a different mechanism of action. Exploring TKP and a specific ratio of polyvinyl alcohol (PVA), citric acid (CA), glucose, acetic acid, sodium bicarbonate, urea, and potassium permanganate, four distinct forms of adhesive have been developed. The produced adhesives were evaluated by the following standardized preparations: solid content, gelling time, FTIR, TGA, viscosity, and single lap joint test for shear strength. The experimental particleboards mechanical and physical attributes were assessed in accordance with ASTM standards. However, the researchers compared the performance of TKP to that of a conventional adhesive, urea formaldehyde (UF), in terms of their ability to bond wood particles and the mechanical properties of the resulting composite materials. The results showed that TKP was an effective adhesive, with comparable bonding strength to UF. The highest bonding strength (5.18 MPa) and fastest gel time were both achieved by adhesive type A. The maximum modulus of rupture (10 N/mm^2) and modulus of elasticity (2108 N/mm^2) were demonstrated by adhesive type B, which has an average density of 0.65 g/cm^3. The researchers also found that the mechanical properties of the composite materials made with TKP were similar to those made with UF, indicating that TKP could be a viable alternative adhesive for the production of wood-based composites. Furthermore, TKP was found to be more environmentally friendly than UF, as it is a natural and renewable resource and does not contain any toxic substances. The impact of various processing conditions on the characteristics of TKP-based adhesives was also studied by the researchers. The strength of bonding of the composites was demonstrated to be improved by increasing the mixing duration and pressure during the adhesive formulation. They also noted that the TKP-based adhesive's bonding strength was increased more significantly with the addition of a small quantity of a crosslinking agent, such as PVA.

To prevent risks to the health of humans and the environment as well as dependence on petroleum-based products, the fabrication of green adhesives from natural resources is of utmost importance. In this work, tamarind seed kernel powder (TKP) was subjected to a number of chemical processes in order to generate environmentally friendly and sustainable adhesives. Particleboards were constructed using the prefabricated adhesives. Physicochemical characteristics of Type A adhesives were superior to those of Type B, C, and D adhesives. Although the prepared adhesives thickness swelling (TS) and water absorption (WA) were still high for the TKP-based adhesives because of their hydrophilic properties, they are unable to match the dimensional stability of particleboards made with UF resin. Further research is needed to optimize the processing conditions and properties of TKP-based adhesives, and to investigate their performance in different types of wood-based composites.

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