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Influence of Layer Architecture on the Mechanical and Optical Properties of Transparent Wood–Glass Fiber Hybrid Laminates

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INTRODUCTION

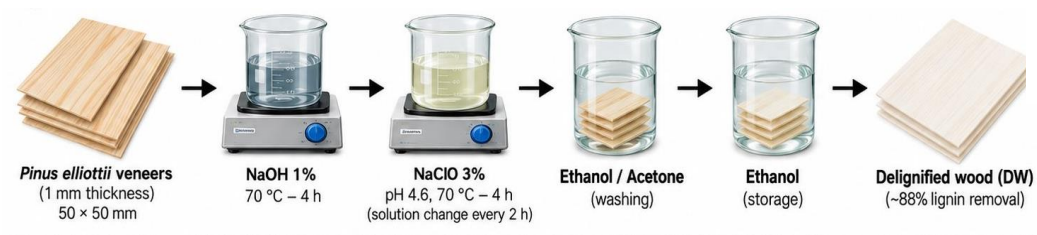
Transparent wood is an emerging material that combines the hierarchical structure of wood with optical transparency through lignin removal and polymer infiltration. Its development offers opportunities for **sustainable and lightweight materials** with potential applications in construction and functional components. The incorporation of **glass fiber** may further **improve mechanical performance** while maintaining optical properties.

OBJECTIVES

To manufacture hybrid transparent wood–glass fiber laminates using *Pinus elliottii* and glass fiber, and to investigate the influence of layer arrangement on their optical and mechanical properties.

METHODOLOGY

1 Wood preparation



2 Resin impregnation





Figure 1. Schematic representation of laminate configurations

RESULTS AND DISCUSSION

The hybrid laminates maintained high optical transmittance, with values of 77% for GPG and 79% for PGG, compared with 78% for the GGG reference. These results indicate that the incorporation of *Pinus elliottii* layers preserved the optical performance of the laminates.

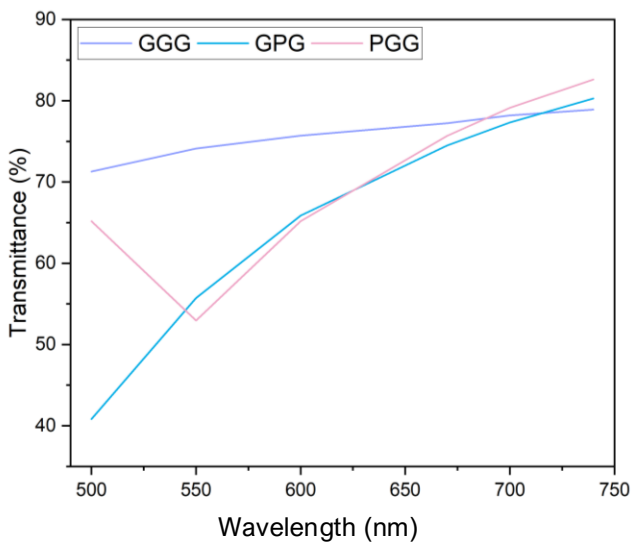


Figure 2. Optical transmittance spectra (500–750 nm) of the laminate configurations: GGG (reference), GPG, and PGG.

The hybrid configurations exhibited substantially improved mechanical performance compared with the GGG reference. **Tensile strength increased from 26.4 MPa to 55.0 MPa for GPG and 57.89 MPa for PGG**, corresponding to improvements of 108.3% and 119.3%, respectively. **Young's modulus also increased, reaching 360.2 MPa for GPG and 431.6 MPa for PGG**, compared with 194.8 MPa for GGG. Maximum deformation showed only moderate variation among the configurations.

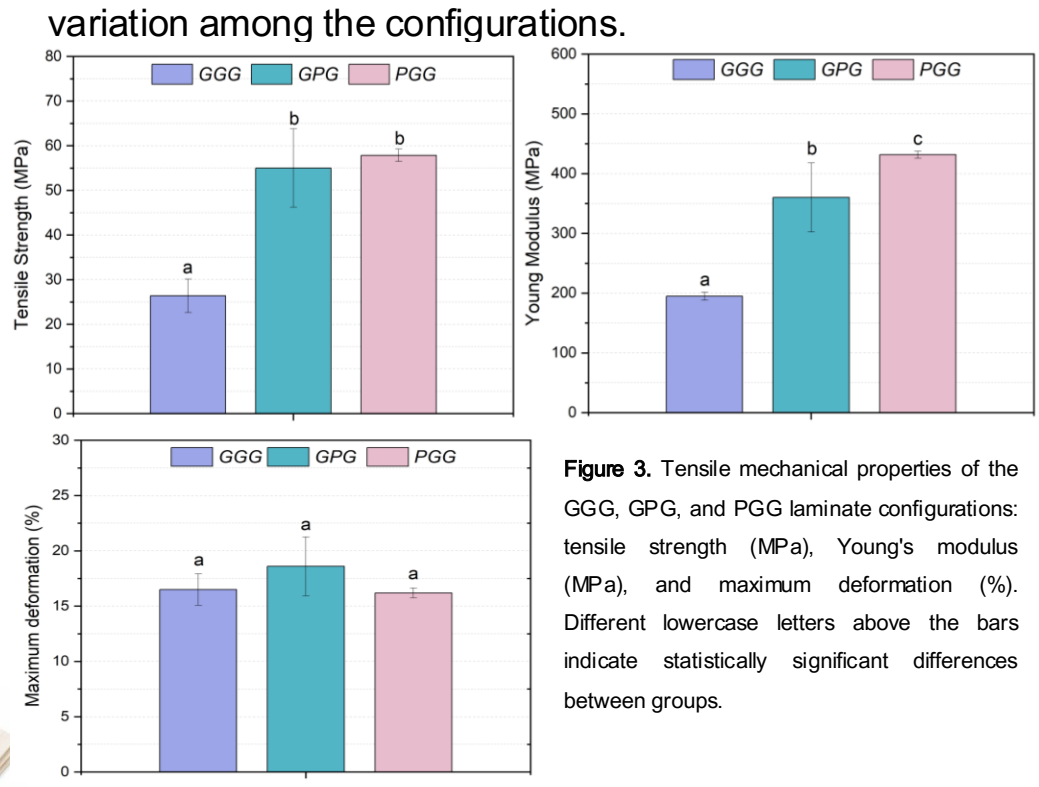


Figure 3. Tensile mechanical properties of the GGG, GPG, and PGG laminate configurations: tensile strength (MPa), Young's modulus (MPa), and maximum deformation (%). Different lowercase letters above the bars indicate statistically significant differences between groups.

SEM micrographs (200×) revealed continuous interfaces between the wood and glass fiber layers, with no evidence of macroscopic delamination. These features suggest effective epoxy resin impregnation and mechanical interlocking within the porous structure of *Pinus elliottii*, contributing to the structural integrity of the hybrid laminates.

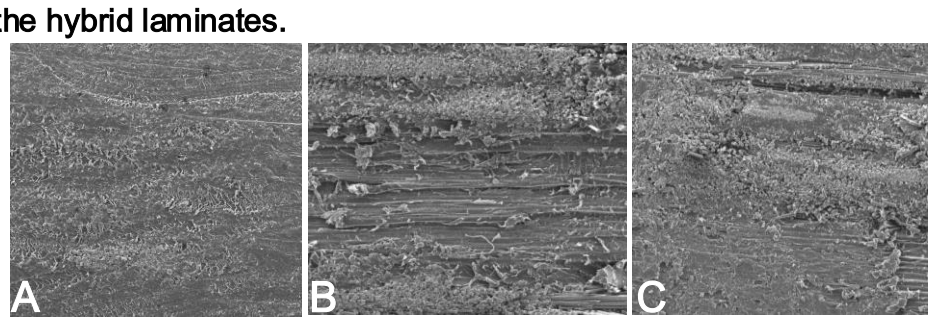


Figure 4. Scanning electron microscopy (SEM) micrographs of the laminate configurations: (A) GGG, (B) GPG, and (C) PGG, obtained at 200× magnification.

CONCLUSIONS

The layer arrangement influenced the optical and mechanical performance of the hybrid transparent wood–glass fiber laminates. Both hybrid configurations maintained high optical transmittance while exhibiting substantially improved tensile strength and stiffness compared with the GGG reference. Among the evaluated configurations, PGG presented the best overall performance, combining 79% optical transmittance, a maximum tensile strength of 57.89 MPa, 431.6 MPa Young's modulus and the lowest apparent density (1.16 g cm^{-3}). These findings highlight the potential of hybrid transparent wood laminates for lightweight, translucent and innovative structural applications, contributing to the development of advanced materials with sustainability potential.

REFERENCES AND ACKNOWLEDGEMENTS

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