Chapter in Book

Transparent Wood for Weather Resistance

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Abstract: *Transparent wood is a sustainable material. This material is promising material becomes one of the selections of transparent building materials. Transparent wood is made by natural wood with synthesis process. Wood is a renewable and earth-abundant resource. Fabrication transparent wood is removed lignin in wood and replaced by a similar refractive index polymer. The fabricated transparent wood with high transmittance and enhanced mechanical properties is a potential material for light-transmitting building materials, magnetic materials and transparent solar cell windows. Cells in the wood are mainly composed of cellulose, hemicellulose and lignin. The hierarchical structure and the strong interactions among cellulose, hemicelluloses, and lignin lead to excellent mechanical properties in wood. Cellulose and hemicelluloses are optically colorless, lignin cause by complex structure is opaque with dark color. Lignin provides high hardness and rigidity to the wood. The wood sample will be washed and immerse in acid then followed by a heat treatment. The properties of transparent wood such as strengthless, flexibility, light transmittance, roughness, thermal resistance and chemical resistance was measured. Transparent wood is a potential material for several sector like building material and solar cell material. Transparent wood can be one of new enable selection sustainable material for some sector.*

Keywords: Transparent Wood; Weather; Resistance; Properties

1. INTRODUCTION

Wood is natural material widely used in human activity. Wood is a renewable and earth abundant resource. Wood has a natural growth process and unique structure as well as attractive mechanical properties. It is sustainable and renewable material means that environmentally friendly (Yaddanapudi et al., 2017). Transparent wood is delignified wood submerged with polymer because it has been high transmittance and improved mechanical properties especially, making it a good candidate for light-transmitting building materials and transparent solar cell windows. The development of transparent wood to replace the commonly used glass or give new materials selection for solar cell windows and building materials. Transparent wood has lower thermal expansive, lighter, better insulation and is stronger than glass (Li et al., 2017, Mi et al., 2019).

Nowadays, energy consumption and energy demand growing every year. Meanwhile, the air pollution caused by burning coal and natural gas is become highly concern by all countries. In human activity in this generation, electricity is the most important energy source. Most of the electricity is generated by burning coal, natural gases and oil which are released a lot of carbon dioxide change the

composition of atmosphere that traps heat similar effect as the glass roof of a greenhouse. To reduce air pollution, scientists and engineers need to develop new sustainable and green energy sources such as solar cells and wind turbines to replace coal and natural gas that release massive greenhouse effect gases. Furthermore, engineers develop some methods to reduce energy consumption and increase the energy efficient. For example, window panels made by low thermal conductivity materials. Transparent wood is the potential to become energy efficient building materials and light management layers for solar cells.

Cells in the wood are mainly composed of cellulose, hemicellulose, and lignin. The hierarchical structure and the strong interactions among cellulose, hemicelluloses, and lignin lead to excellent mechanical properties in wood. Cellulose and hemicelluloses are optically colourless, and lignin caused by complex structures is opaque with dark colour. Lignin provides high hardness and rigidity to the wood (Yaddanapudi et al., 2017, Kai et al., 2018).

The process of fabrication of transparent wood is utilized a chemical reaction to bleach the wood (remove lignin to increase transparency) and infiltrate polymethyl methacrylate (PMMA). Due to the removal of lignin, wood becomes high optical transmittance and low haze. Polymers replace lignin as the structure of wood. Transparent woods strengthen is related to the type of polymer used (Ali et al., 2015). To make high toughness needs to use a suitable polymer. Because transparent wood is the potential material on building material and solar cell windows. Investigating its performance on weather resistance is necessary. Weather will be corrosion transparent wood by wind, acid rain, and other natural weather.

To apply a transparent wood, engineers need to consider several factors that exist in the actual situation. For example, thermal phase change, extreme environment, hardness, strength, chemical resistance, ductility, and optical properties.

2. OPTICAL MEASUREMENT

Balsa trees is the type of lowest density tree species, cause by its fast growth rate due to lower lignin in wood compared to some other species of wood. To fabricate transparent wood, I immersed the wood in $NaClO_2$ at 95^oC for 12 hours then immersed the wood in H_2O_2 for 12 hours for further delignification. H_2O_2 treatment is to reduce light absorbing in wood, with low delignification (Li et al., 2017). Lignin is the main reason cause the brownish wood colour. The aromatic structure of wood undergoes oxidative ring-opening reaction to form acidic groups in $NaClO_2$-based delignification processes that make the lignin more soluble in water. Alkaline H_2O_2 treatment is removed and alter chromophore structure of lignin, while this treatment enables preserved the bulk lignin.

UV-visible spectrophotometry is spectra of fabricate transparent wood with different thickness. Figure 1 show the result of the optical transmittance and haze measurement of the transparent wood with different thickness. From the data collected, increasing the thickness of wood substrate have greater light attenuation and lower transmittance. Because of the increased absorption and a greater number of detects that act as scattering sites.

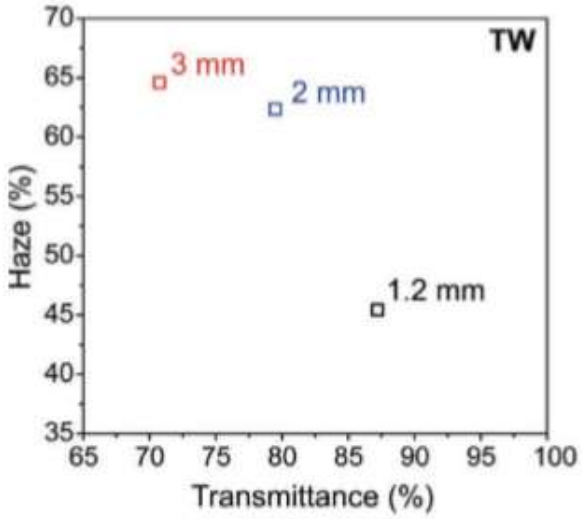

Figure 1. Optical transmittance measurement of the transparent wood with different thickness (Montanari et al., 2021)

Hardness of transparent wood is tested by Rockwell Hardness C-scale tester. Data collected will compare to the common material of window. The density of original wood and transparent wood is measured.

3. TENSILE TEST

The tensile strength of transparent wood samples was related to their thickness, fabricate method, type of polymer infiltrated, lignin content and chemical structure. The tensile strength test by universal testing machine is measured with different thickness of transparent wood. Figure 2 show the stress and strain relationship of original wood, delignified wood, transparent wood.

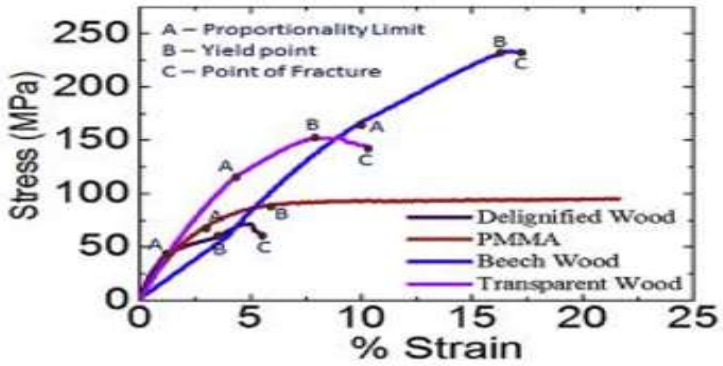

Figure 2. The stress and strain relationship of original wood, delignified wood, transparent wood (Yaddanapudi et al., 2017)

The comparison of colour change of transparent wood before and after expose under sunlight for 1, 2, and 3 weeks. Figure 3 show that the picture of transparent wood samples before expose under sunlight and after exposed under sunlight for 1-3 weeks.

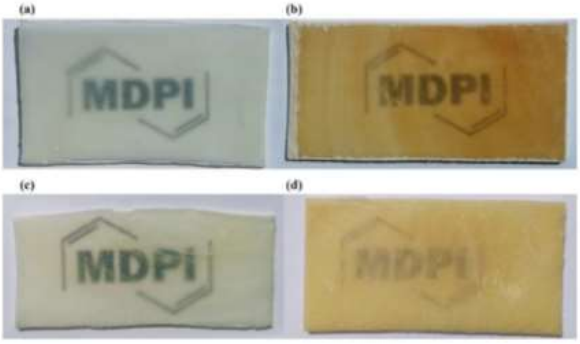

Figure 3. Picture of transparent wood samples before expose under sunlight and after exposed under sunlight for 1-3 week (Wachter et al., 2021)

5. CONCLUSION

This review present a future application of transparent wood as weather resistance. Researchers show a promising properties of the transparent wood based on the optical measurement and tensile test.

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