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Dimensional Stability and Dynamic Young's Modulus of Tropical Light Hardwood Chemically Treated with Methyl Methacrylate in Combination with Hexamethylene Diisocyanate Cross-Linker

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ABSTRACT: Chemical treatment is often used to improve the physical and mechanical properties of wood materials. In this study, wood polymer composites (WPC) were prepared from five types of tropical wood species by impregnating the woods with methyl methacrylate (MMA) combined with a cross-linker hexamethylene diisocyanate (HMDIC). Their dimensional stability and mechanical properties were then investigated. The impregnation of wood with monomer systems and polymerization was accomplished through vacuum-pressure and catalyst heat treatment method, respectively. The manufacturing of WPC was confirmed through FT-IR spectroscopy and X-ray diffraction (XRD) analyses. The dimensional stability of manufactured WPC in terms of volumetric swelling (S) and antishrink efficiency (ASE) was measured and found to be improved on treatment. In addition, the modified WPC had lower moisture absorption and higher water repellent efficiency compared to raw wood. The mechanical property of treated samples in terms of dynamics Young's modulus (E_d) was also shown to improve. These improvements in properties were observed as more effective with MMA−HMDIC combination.

1. INTRODUCTION

In the past few years, interest in chemical modification of solid wood has been increasing due to the extreme shortage of good quality hardwood in the world. This trend has inspired the researchers to search for an alternative way to develop higher quality wood from low quality samples. Wood is a renewable resource and one of the most preferred building materials because of its complex structure and its universal practicality. Generally, wood is a natural polymeric material, made up mainly of cellulose, hemicelluloses, and lignin. These three polymer components are the most important responsible factors for the physical, mechanical, and thermal properties of wood. The physical and chemical properties of wood are readily deteriorated by weathering effects such as light, water, temperature, biological organisms, and others.[1] The main problems associated with wood for outdoor and indoor uses are its dimensional instability due to high moisture uptake, biodegradation, and decay by microorganisms.[2−4] These defects are due to the presence of numerous hydroxyl groups (−OH) in the three major wood components and their various cavities. The −OH groups of wood attract water molecules through hydrogen bonding, thus making it dimensionally unstable, which in turn promotes physical, mechanical, and chemical properties changes. Chemical modification of cell wall polymer is an often-followed route to improve these inherent properties.[5] More precisely, modification using suitable chemical treatments such as the formation of wood polymer composites (WPC) shows potential in improving wood properties.[6−8] Impregnating wood with polymerizable monomer formulation and then polymerizing it in place produces a WPC. The WPC is more convenient as a product material compared to plain wood as it is less susceptible to moisture-induced swelling, shrinking, and thermal degradation. Consequently, it has a longer life-span. Moreover, the WPC has a smoother surface structure.

Recent considerable interest has been manifested in wood impregnation with a variety of monomers such as styrene, epoxy resins, urethane, phenol formaldehyde, methyl methacrylate (MMA), vinyl, and acrylic monomer to improve the negative properties in wood.[9−11] WPC made with combinations of monomers like hexadiol, diacrylate, hydroxyethyl methacrylate, glycidyl methacrylate, and anhydride has been shown to improve the dimensional and thermal stability.[12] However, it has been established that most monomers do not form bonds with hydroxyl groups of cell wall polymer. Since most monomers are nonpolar, there is little interaction between these monomers and the hydroxyl groups of the wood component. Poor chemical and physical interfacial interactions between the wood surface and chemical are two of the most important causes of bond failure. Therefore, the polymer component of the WPC simply bulks the wood structure by filling the capillaries, vessels, and other void spaces within the wood. They simply bulk the void spaces within the wood structure. It can therefore be deduced that if there is a bond between the impregnated monomers and the hydroxyl groups of wood, the dimensional stability and mechanical and physical properties of WPC may be improved further. It has been noted that adhesion and interaction between wood component and polymer can be enhanced by using varieties of

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