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FACTORS INFLUENCING WOOD MODIFICATION IN NIGERIA

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Abstract
The paper review factors influencing wood modification, which involves altering the physical, chemical, or biological properties of wood to enhance its performance. Population increase and increase in demand for wood product has put pressure on the preferred timbers. The primary objective is to explore the potential of wood modification to improve wood's properties, particularly addressing issues like dimensional instability and decay. Comprehensive approach was employed to review the wood modification process in Nigeria. The study review that wood modification, specifically thermal modification, can significantly enhance the dimensional stability, decay resistance, and strength properties of Nigerian wood species. However, despite the positive outcomes, wood modification technologies have not gained widespread acceptance among researchers and stakeholders in Nigeria's wood industry. This lack of adoption has resulted in limited investment and insufficient dissemination of research information. The wood industry in Nigeria faces challenges related to sustainability and the quality of wood products. The study emphasizes the urgent need for increased awareness and investment in wood modification technologies. By embracing wood modification techniques, Nigeria can enhance the value and sustainability of its wood products, thereby contributing to sustainable forest management and meeting the demand for high-quality wood-based goods.

Key Words: *Wood modification, Dimensional stability, Decay, Resistance, Strength properties*

Introduction

Wood modification involves the action of a chemical, biological, or physical agent upon the material, resulting in a desired property enhancement during the service life of the modified wood (Hill, 2006). It can be regarded as a method used to improve the properties of the service life of wood for numerous centuries. The primary goal of wood modification is to explore the possibility of modifying wood's properties to enhance its performance and minimize the risks associated with its use, particularly concerning issues such as dimensional instability and decay. Moisture is a critical factor that significantly affects both these aspects of wood behavior. Wood is

considered a hygroscopic material, which means that it can absorb water from its surroundings (Liu *et al*., 2021). Due to its anisotropic nature, wood expands and contracts differently in the radial and tangential directions of the growth rings as well as in the direction of the grain (Mohan *et al*., 2018). As the wood dries, it undergoes shrinkage, ranging from being completely wet to fully dry (Gurau *et al*., 2020).

Nowadays, the wood moisture content is the most important input variable in many service life and performance prediction models, both in engineering and natural sciences (Brischke and Thelandersson, 2014). Shrinking and swelling occur as the wood changes moisture content in response to daily as well as seasonal changes in the relative humidity of the atmosphere, i.e., when the air is humid, wood adsorbs moisture and swells; when the air is dry, wood loses moisture and shrinks. Similarly, air drying and kiln drying may not entirely prevent the wood from undergoing moisture changes (Singh, 2006; USDA Forest Service, 2010). Despite being a natural product sourced from individual trees, the use of wood is constrained, and it must undergo modification to attain the intended functionality. This is due to the inherent weaknesses of the material, such as sensitivity to moisture, low dimensional stability, poor hardness, and wear resistance, susceptibility to fungal, termite, and marine borer attacks, as well as inadequate resistance to UV radiation.

Sustainable Wood Utilization in Nigeria

Wood has been an essential part of Nigerian culture and economy for centuries, with a variety of uses ranging from cooking and construction to furniture making and traditional ceremonies (Ajibola *et al*., 2020). Nigeria is one of the largest exporters of tropical hardwoods in Africa, reflecting the country's significant reliance on wood-based products (UNEP, 2021). Wood is widely used for building and construction in Nigeria, particularly in rural areas where modern building materials are expensive and hard to come by (Ajibola *et al*., 2020). Wood is used to make roofing materials, doors, windows, and other structural components. However, the use of wood for building also contributes to deforestation, a major environmental issue in Nigeria (UNEP, 2021). Additionally, wood is an integral part of many traditional ceremonies, such as weddings, funerals, and festivals, with wooden masks and sculptures being common features (Oluwatayo, 2016). These trees are usually found in tropical rainforests and are harvested by experienced loggers using traditional methods (Adaramola *et al*., 2021). In furniture making, wood is preferred for its natural beauty, warmth, and elegance, as well as its versatility in creating various furniture designs (Ajibola *et al*., 2020).

Wood Modification Characteristics

A common method of wood modification is chemical treatment, which involves impregnating the wood with chemicals that alter its structure and properties. The most common chemical treatments include acetylation, furfurylation, and heat treatment. Acetylation involves the reaction of wood with acetic anhydride, which replaces the hydroxyl groups in the wood with acetyl groups, resulting in improved dimensional stability and durability (Rautkari *et al*., 2016). Furfurylation, on the other hand, involves the impregnation of wood with

furfuryl alcohol, which reacts with the wood's cell wall polymers to form a polymer matrix, resulting in increased dimensional stability and strength (Esteves *et al*., 2011). Heat treatment, also known as thermal modification, involves heating wood to high temperatures in the absence of oxygen, resulting in the breakdown of hemicelluloses and lignin, resulting in improved dimensional stability and reduced moisture uptake (Yildiz, 2002). Physical treatment involves the application of mechanical force or pressure to alter the wood's properties. This method includes compression, densification, and impregnation. Compression involves the application of pressure to wood in the radial or tangential direction, resulting in improved dimensional stability and strength (Samarasinghe *et al*., 2019). Densification involves the impregnation of wood with resin or polymer and the application of heat and pressure, resulting in increased density and strength (Lu *et al*., 2014). Biological treatment involves the use of fungi or bacteria to modify the wood's properties. This method includes decay protection, in which fungi are used to protect the wood from decay, and bio-pulping, in which fungi are used to remove lignin from wood fibers, resulting in improved pulp quality (Nugroho *et al*., 2021). In Nigeria, wood modification has gained increasing attention in recent years due to the need for sustainable forest management and the demand for high-quality wood products. One of the most common wood modification techniques used in Nigeria is thermal modification. This process involves heating the wood to high temperatures in the absence of oxygen, which changes the chemical and physical properties of the wood. According to a study by (Oluyege *et al*., 2020).

Another wood modification technique used in Nigeria is the chemical modification, which involves impregnating the wood with chemicals to improve its properties. For example, a study by (Akinwande *et al*., 2019) investigated the effect of chemical modification using a mixture of propylene oxide and acetic anhydride on the properties of rubber wood. The results showed that the modified wood had improved dimensional stability, water resistance, and hardness. Wood modification in Nigeria is also driven by the need to reduce the reliance on imported wood products and promote local content development. Adeyemo *et al*., (2020) reported the potential of locally sourced bamboo as a sustainable alternative to imported wood for furniture production. Wood modification is a crucial procedure that can enhance the characteristics of wood species suitable for different uses. It has significant potential to enhance the quality and durability of Nigerian wood products and promote sustainable forest management. Chemical, physical, and biological treatments are the popular techniques employed in the modification of wood, which can enhance its strength, durability, and dimensional stability, and protect it from biological deterioration. However, there is a need for further research and development to optimize the techniques and processes for different Nigerian wood species and applications.

Factors Influencing Wood Modification in Nigeria

Wood Species: Different wood species have varying characteristics that influence

their modification. The properties of wood, such as its density, permeability, and extractive content, vary across different species, which can affect how easy or difficult it is to modify them. Hardwood species, such as oak and ash, have high density, low permeability, and high extractive content, which can make them more challenging to modify, Esteves and Pereira, (2009). Hardwoods have a more complex and heterogeneous structure than softwoods, which can make the diffusion of chemicals used in modification processes slower and more challenging (Esteves and Pereira, 2009), softwoods have a simpler and more uniform structure than hardwoods, which can facilitate the diffusion of chemicals and make the modification process more efficient. Softwoods are also more abundant and less expensive than hardwoods, which can make them a more viable option for wood modification. Moreover, the anatomy of wood also plays a crucial role in its modification. The presence of resin canals, tyloses, and extractives can affect the treatment process, as noted by (Bekhta *et al*., 2013). For instance, resin canals, which are more common in softwoods, can hinder the diffusion of chemicals and affect the final properties of the modified wood. Tyloses, which are outgrowths from the wood cells, can also limit the penetration of chemicals and affect the durability of the modified wood. Extractives, which are chemical compounds found in wood, can affect the colour, stability, and toxicity of the modified wood, depending on their type and concentration

Moisture Content: High moisture content in wood can hinder the diffusion and penetration of chemical agents into the wood cells. This is because water molecules occupy the available space in the wood cells and impede the movement of chemical agents. As a result, the chemical modification process may not be effective, and the wood may not achieve the desired properties. On the other hand, low moisture content can also result in poor diffusion and inadequate retention of chemical agents (Yildiz, 2002). This is because the wood cells may not have enough water to facilitate the movement and retention of the chemical agents. Acetylation requires low moisture content to achieve maximum penetration and retention of acetyl groups. (Esteves and Pereira, 2009) found that acetylation of wood with moisture content above 20% resulted in inadequate acetyl group retention.

Treatment Conditions: The conditions under which wood modification takes place, such as temperature, pressure, and duration, have a significant influence on the extent and nature of the modifications. When wood is subjected to thermal modification, the hemicelluloses and lignin present in the wood are degraded due to the high temperature. The extent of degradation of these components depends on the treatment temperature, duration, and the presence of other factors such as moisture content and oxygen. Studies have shown that the degradation of hemicelluloses and lignin increases with increasing temperature and duration of the thermal treatment (Tjeerdsma *et al*., 1998). The crystallinity of cellulose, which is the most abundant component of wood, also increases during thermal modification. This is due to the removal of amorphous regions of cellulose, which increases the degree of polymerization and crystallinity of cellulose (Yildiz *et al*., 2006).In addition to temperature and

duration, the presence of other factors such as moisture content and oxygen can also affect the extent and nature of the wood modification. For example, high moisture content can limit the extent of degradation of hemicelluloses and lignin during thermal modification, while the presence of oxygen can result in the formation of oxidative products (Tjeerdsma *et al*. 1998).

Chemical Agents: The choice of chemical agents used in wood modification affects the properties of the modified wood. Different agents have varying affinities for different wood components, resulting in varying degrees of modification. (Rowell 2006). The concentration and type of chemical agents used also affect the degree of modification.

Wood Dimensions: The size and shape of the wood also affect the modification process. The penetration and retention of chemical agents in wood are affected by the surface area to volume ratio, with smaller wood pieces achieving deeper and more uniform modifications (Esteves and Pereira 2009). The thickness of the wood also affects the rate and extent of heat penetration, with thicker pieces requiring longer heating durations to achieve desired modifications (Tjeerdsma *et al*. 1998).

Natural Factors: Nigeria is blessed with a wide range of tree species, however, not all of these species are suitable for wood modification. According to (Olufemi *et al*., 2016), the suitability of a wood species for modification depends on its anatomical and physical characteristics. Some of the factors that determine the suitability of a wood species for modification include the presence of extractives, the density of the wood, the moisture content, and the size of the cells. These factors influence the extent to which a wood species can be modified and the quality of the modified wood. For instance, hardwood species such as Tectonagrandis and Triplochitonscleroxylon are suitable for thermal modification due to their low extractives content, high density, and large cell size (Ogunsanwo *et al*., 2020b).

Socio-Economic Factors: The demand for wood products in Nigeria is high due to rapid population growth and urbanization. However, the supply of wood is limited due to deforestation, illegal logging, and poor forest management practices (Ogunsanwo *et al*., 2020a). This has led to an increase in the price of wood products and a shift towards the use of alternative materials such as plastic and metal. Wood modification can help to increase the durability and lifespan of wood products, thereby reducing the need for frequent replacement and increasing their value (Ogunsanwo *et al*., 2020c). However, the high cost of wood modification processes and lack of awareness among wood product manufacturers and consumers have been identified as barriers to the adoption of wood modification in Nigeria (Olufemi *et al*., 2016).

Technological Factors: The type of wood modification process used in Nigeria is influenced by the availability of technology and expertise. According to (Olufemi *et al*., 2016), thermal modification is the most commonly used wood modification process in Nigeria due to the availability of local technologies and equipment. Chemical modification and impregnation with preservatives are less common due to the high cost of imported chemicals and equipment. However, research has shown that

chemical modification and impregnation with preservatives can produce more durable and stable wood products compared to thermal modification (Ogunsanwo *et al*., 2020e). Meanwhile, the wood modification process in Nigeria is influenced by a combination of natural, socio-economic, and technological factors. The suitability of wood species for modification, the demand for wood products, and the availability of technology and expertise all play a role in determining the type and extent of wood modification in Nigeria. Despite the challenges facing the wood industry in Nigeria, there is a need for increased awareness and investment in wood modification technologies to increase the value and sustainability of wood products in the country.

General Benefits of Wood Modification in Nigeria

Improved Durability: Modified wood has better resistance to decay, rot, insect attack, and weathering than unmodified wood (Zaman *et al*., 2020). This is because the modification process alters the chemical composition of the wood, making it more resistant to environmental factors that can cause degradation. Wood modification has been used to improve the durability of locally sourced wood species in Nigeria, such as iroko, mahogany, and teak, which are commonly used in construction and furniture making. According to (Okoh *et al*., 2019), wood modification can improve the resistance of wood to fungal decay and insect attack, which are major problems in Nigeria due to the country's high humidity and temperature. Hence, modified wood can last up to 50 years, compared to unmodified wood, which has a lifespan of between 10 to 15 years Okoh *et al*., 2019)

Increased dimensional stability: Modified wood has reduced moisture uptake and swelling, which makes it less susceptible to warping, splitting, and cracking (Esteves and Pereira, 2009). This improved stability is due to the reduced hydrophilic nature of the modified wood. Wood is prone to shrinkage and swelling due to changes in moisture content, which can lead to warping, cracking, and other forms of damage. However, wood modification can reduce the hygroscopicity of wood, making it less susceptible to moisture-related problems (Ogunsanwo *et al*., 2020d). This makes modified wood more suitable for use in outdoor applications, such as decking, cladding, and fencing.

Enhanced mechanical properties: Wood modification can also enhance the mechanical properties of wood. Modified wood can have higher strength, stiffness, and hardness than unmodified wood (Yildiz *et al*., 2006). This is because the modification process can improve the intermolecular bonding within the wood structure, leading to a more uniform and stronger material.

Better fire resistance: Wood modification can also improve the fire resistance of wood. Modified wood has a higher ignition temperature, slower burning rate, and reduced smoke and toxic gas emissions than unmodified wood (Candelier *et al*., 2014). This is due to the chemical changes that occur during the modification process, which can result in the formation of char that acts as a protective layer against fire.

Aesthetic improvement: Wood modification can also enhance the aesthetic properties of wood. Modified

wood can have a more uniform colour, reduced knots, and improved texture and grain pattern than unmodified wood (Hill, 2006). According to (Adefisan*et al*., 2021), modifications such as heat treatment and chemical treatment can darken the colour of wood, making it more visually appealing. This can make it more appealing for use in high-end applications such as furniture, flooring, and decking. These benefits have led to the increased adoption of wood modification in various industries, including construction, furniture, and decking.

Conclusion

The modification of wood in Nigeria can be influenced by factors such as wood species, moisture content, treatment conditions, chemical agents, and wood dimensions. Different wood species have varying characteristics that affect their modification, such as density, permeability, and extractive content. Despite the challenges facing the wood industry in Nigeria, there is a need for increased awareness and investment in wood modification technologies to increase the value and sustainability of wood products in the country.

Recommendations

Based on the factors influencing wood modification in Nigeria, the following recommendations could be drawn;

- More research should be conducted to investigate the potential of locally available wood species for modification, as well as the most effective modification techniques for each species.
- To facilitate the adoption of wood modification techniques, the Nigerian government should invest in the necessary infrastructure, such as drying and treatment facilities, to ensure that modified wood products meet the required quality standards.
- Collaboration between government agencies, private sector players, and research institutions should be encouraged to promote the exchange of information and expertise and accelerate the development of the wood modification industry in Nigeria.
- The Nigerian government should provide incentives, such as tax breaks and financial support, to encourage the development of the wood modification industry and promote the use of modified wood products. This could also include creating policies that mandate the use of modified wood products in certain applications, such as construction and furniture making.

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