

Future Prospects of Wood Preservation with Nanotechnology

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As a natural material, wood is susceptible to many hazards, including biological agents, fire, and weathering. Over millennia of utilization of wood in many applications, human beings have developed practical methods to protect it. High specific surface presented by nanotechnology has provided improved effectiveness of nano-materials, though low amount of materials are used. This can cut material costs as well as reduce environmental hazards caused by the release of wood preservatives as poisons and biocides. Many promising projects have been carried out in the last decade or so, indicating the potentiality of using different nano-materials in wood and wood products preservation. However, there are still numerous other aspects and materials that can be investigated at nano-scale to enhance the quality of living for generations to come. Researchers should always keep in mind that cost/benefit is vital for the commercial sector.

Keywords: Biological agents; Deterioration; Nanotechnology; Preservation; Wood and Wood-composites

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Wood can last for centuries provided it is not attacked by organisms seeking food, shelter, or both (Schmidt, 2006). These biological agents include different kinds of wood-deteriorating fungi, wood-boring insects, termites, and marine borers (Milton 1995). To protect wood from biological attack or fire, many materials have been introduced at the laboratory and industrial scale (Schmidt, 2006, 2007; Taghiyari 2012). In recent years, nano-materials have also been successfully added to preservatives to protect wood against wood-rotting fungi (Karimi *et al.* 2013; Lykidis *et al.* 2013; Taghiyari *et al.* 2014a,b; Mantanis *et al.* 2014). Nanosilver (NS) and nanocopper (NC) have been reported to be effective in limiting the growth of *Trametes versicolor* in commercial particleboard panels (Taghiyari *et al.* 2014a). The cited authors found that copper nanoparticles not only protected the test material against *T. versicolor*, but also they contributed to an increased hardness. This was attributed to better heat-transfer from the hot-plates to the particle mat, facilitating better cure of the resin. They found out that panels treated with 150 mL of 200 ppm nanosilver suspension demonstrated lower decrease in hardness after the exposure to *T. versicolor* (Taghiyari and Norton 2014). In another research project, borate and copper oxide nanoparticles were tested against mold and decay fungi and subterranean termites (Mantanis *et al.* 2014). The authors reported that mold fungi were slightly inhibited by nanozinc borate, while the other nanometal preparations did not inhibit mold fungi. Mass loss from fungal attack by *Trametes versicolor* was also inhibited by the zinc-based compounds. They also indicated that all

pine specimens treated with nanozinc borate strongly inhibited termite feeding, with mass losses in the range 5.2 to 5.4%. In contrast, the copper-based treatments were much less effective against subterranean termites, *Coptotermes formosanus* (Mantanis *et al.* 2014).

Although the addition of metal nano-particles has been reported to be significantly effective in hindering biological agents' activities, no particular report has so far confirmed application of metal nano-particles at a commercial scale. Therefore, researchers have turned to other materials that are cheaper than silver or copper, as well as being abundant in many countries. They also have investigated the potentiality of using materials at micro-scale to even reduce the production costs. In this regard, wollastonite was found to be effective in reducing the effects of certain pathogens, including fungi (Aitken 2010; Karimi *et al.* 2013). It is also nontoxic to humans or wildlife (Huuskonen *et al.* 1983; Maxim and McConnell 2005). Wollastonite at nano and micro scales has been reported to significantly improve biological resistance of wood and wood composites (Karimi *et al.* 2013; Taghiyari *et al.* 2014ab). The improving effect was partly as a result of the impact of wollastonite on permeability of the treatments (Taghiyari and Sarvari Samadi 2015).

Other mineral materials, such as nanoclay, were also successfully used in wood-plastic-composite (WPC) materials to evaluate improvement in biological resistance to five different fungi (Bari *et al.* 2015). SiO₂ nanopowder was also studied and compared with TiO₂ nanopowder and nanoclay (Devi and Maji 2013).

CONCLUSIONS

So far, different nano-materials have been separately investigated to enhance particular properties. However, future horizons may include combined application of nano-materials to enhance different wood shortcoming including biological susceptibility and fire. This way, researchers may not only improve wood and wood composites from all aspects, but they can also find inter-actions of materials. Moreover, practical application of nano-materials necessitates logical cost/benefit ratio for the commercial sector.

ACKNOWLEDGMENT

Author appreciates the scientific support of Dr. Jack Norton as his valued mentor (retired from Horticulture & Forestry Science, Queensland Department of Agriculture, Forestry and Fisheries, Australia).

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Article Submitted: February 10, 2015; Peer review completed: April 25, 2015; Revised version received and accepted: May 12, 2015; Published: June 5, 2015.