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 attach 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). SiO_2 nanopowder was also studied and compared with TiO_2 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.

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REFERENCES CITED

Aitken, E. (2010). Analyses of the Effect of Silicon on Fusarium Wilt on Banana. Horticulture Australia, Sydney, NSW, Australia.

Bari, E., Taghiyari, H. R., Schmidt, O., Ghorbani, A., and Aghababaei, H. (2015). "Effects of nano-clay on biological resistance of wood-plastic composite against five wood-deteriorating fungi," *Maderas. Ciencia y Tecnologia* 17(1), 2015-212.

Devi, R. R., and Maji, T. K. (2013). "Effect of nanofillers on flame retardancy, chemical resistance, antibacterial properties and biodegradation of wood-styrene acrylonitrile co-polymer composites," *Wood Science and Technology* 47, 1135-1152.

Huuskonen, M. S., Jarvisalo, J., Koskinen, H., Nickels, J., Rasanen, J., and Asp, S. (1983). "Preliminary results from a cohort of workers exposed to wollastonite in a Finnish limestone quarry," *Scandinavian Journal of Work, Environment, and Health* 9(2), 169-175.

Karimi, A., Taghiyari, H. R., Fattahi, A., Karimi, S., Ebrahimi, Gh., and Tarmian, A. (2013). "Effects of wollastonite nanofibers on biological durability of poplar wood (*Populus nigra*) against *Trametes versicolor*," *BioResources* 8(3), 4134-4141.

Lykidis, C., Mantanis, G., Adamopoulos, S., Kalafata, K., and Arabatzis, I. (2013). "Effect of nano-sized zinc oxide and zinc borate impregnation on brown-rot resistance of black pine (*Pinus nigra* L.) wood," *Wood Material Science & Engineering* 8(4), 242-244.

Mantanis, G. I., and Papadopoulos, A. N. (2010). "The sorption of water vapour of wood treated with a nanotechnology compound," *Wood Science and Technology* 44(3), 515-522.

Maxim, L. D, and McConnell, E. E. (2005). "A review of the toxicology and epidemiology of wollastonite," *Inhalation Toxicology* 17(9), 451-466.

Milton, F. T. (1995). *The Preservation of Wood, A Self Study Manual for Wood Treaters*, Minnesota Extension Service, University of Minnesota, College of Natural Resources, BU-6413-S, Revised 1995, pp. 103.

Schmidt, O. (2006). *Wood and Tree Fungi: Biology, Damage, Protection, and Use*, Springer-Verlag Berlin Heidelberg; 334 pp.

Schmidt, O. (2007). "Indoor wood-decay basidiomycetes: Damage, causal fungi, physiology, identification and characterization, prevention and control," *Mycological Progress* 6(4), 261-279. DOI 10.1007/s11557-007-0534-0.

Taghiyari, H. R. (2012). "Fire-retarding properties of nano-silver in solid woods," *Wood Science and Technology* 46(5), 939-952. DOI 10.1007/s00226-011-0455-6.

Taghiyari, H. R., and Norton, J. (2014). "Effect of silver nanoparticles on hardness in medium-density fiberboard (MDF)", *iForest – Biogeosci. and Forestry* 8, 677-680.

Taghiyari, H. R., Bari, E., Schmidt, O., Tajick Ghanbary, M. A., Karimi, A., and Tahir, P. M. D. (2014a). "Effects of nanowollastonite on biological resistance of particleboard made from wood chips and chicken feather against *Antrodia vaillantii*," *International Biodeterioration and Biodegradation* 90, 93-98.

Taghiyari, H. R., Bari, E., and Schmidt, O. (2014b). "Effects of nanowollastonite on biological resistance of medium-density fiberboard against *Antrodia vaillantii*," *European Journal of Wood and Wood Products* 72(3), 399-406. DOI: 10.1007/s00107-014-0794-8.

Taghiyari, H. R., and Sarvari Samadi, Y. (2015). "Effects of wollastonite nanofibers on fluid flow in medium-density fiberboard," *Journal of Forest Research* DOI 10.1007/s11676-015-0137-6.

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