A Test of High Intensity Ultrasound for the Phytosanitation of Wood

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Abstract

The potential for high intensity ultrasound for the phytosanitation of wood products was tested using decay (rot) and mold fungi and termites. The treatment was not effective in killing these organisms in wood.

Ultrasound is cyclic sound pressure at a frequency above human hearing. Sonicators convert electrical energy into mechanical vibration. At high intensity ultrasound (HIUS), the sonotrode emits those vibrations into the surrounding medium, which causes cavitation in liquids. Alternating high and low pressure create small vacuum bubbles, which then implode (cavitate). The implosion of these bubbles creates localized areas of very high pressure and temperature within the liquid (Piyasena et al. 2003).

Ultrasound is commonly used for cleaning and extraction. The cavitation process produces shock waves that hit solid surfaces and dislodge contaminants. HIUS is also effective in inactivating a wide range of microorganisms (e.g., bacteria, fungi, protozoa) in many liquids (water, milk, juice; Jiranek et al. 2008). The application of HIUS for cleaning and extracting wood has been investigated (Caldeira et al. 2004, Jiranek et al. 2008, Yap et al. 2008) and a commercial system for sanitizing wood wine barrels has been developed (http://www.cavitus.com/wine-barrel-cleaner.html).

There are only a few methods available for phytosanitizing wood products (International Plant Protection Convention 2009) and more options are desired as international trade and concerns over exotic pests increase. The purpose of this preliminary study was to explore the potential of HIUS as a phytosanitary technique for wood infested with common pests: decay and mold fungi and termites.

Methods and Results

High intensity ultrasonic device

A high intensity ultrasonic device with a ¼-inch (6-mm) micro tip was used for all tests (20 kHz, 600 W, Misonix 3000M, Newton, Connecticut). For sonication treatment, the wood samples were mounted on an aluminum plate to assure a fixed position and to keep the sample under the water surface. A few drops of ethanol were added to reduce the surface tension of water to enhance the effect of cavitation. The sonotrode was submerged to a distance of 5 mm from the wood sample surface in 100 mL of water. Treatment times and impulse durations (on/off cycles) were varied, but the intensity was maintained at the highest setting on the machine (≈1,500 V rms). In food processing, sonication times are generally short, i.e., 30 minutes or less (Piyasena et al. 2003). The treatment times chosen for this exploratory study varied for the different tests and ultimately ranged from a few minutes to an hour. The initial intent was to optimize the treatment conditions for wood substrates, and treatment times were relatively short; however, as the study progressed and the treatments proved ineffective, longer treatment times were applied. The water temperature in the treatment beaker was monitored and an ice bath was used to ensure that the water temperature did not exceed 35°C. High intensity ultrasonic treatment increases water temperatures, and the use of the ice bath was intended to isolate the possible effect of ultrasonic cavitation from lethal hot water temperatures.

Termite test

Subterranean termites (*Reticulitermes* spp.) were collected from wood in a forest in Knox County, Tennessee. A single living worker termite was inserted into a hole (8-mm

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diameter) that had been drilled in a 25-mm cube of dry poplar wood. Each hole was closed tightly with a wooden plug, leaving a space at the bottom of the hole for the termite. This sample configuration is probably not a realistic representation of termite galleries, which are not sealed and usually are within and contain wet wood and other material. However, it was chosen as a convenient and easily replicable method that represents a worst-case scenario.

Replicate blocks (three per treatment) were submerged in water and exposed to ultrasound for 30 minutes in total, with on/off cycles ranging from 5 minutes on and 1 minute off to 30 minutes on (five different treatment conditions). A total of 15 samples were treated. After treatment the blocks were split to expose the termite chamber. In all cases, the termites were alive and mobile, with no visible symptoms of any negative effects.

Decay fungi test

A stem section from a hickory tree (*Carya* spp.) naturally infested with a white-rot decay fungus (species not determined) was collected from the forest. Blocks were cut from the section for HIUS treatment. Dry, defect-free 19-mm poplar (*Liriodendron tulipifera*) cubes also were prepared in the laboratory and inoculated with the white rot fungus *Trametes versicolor*. The inoculated blocks were incubated for 2 weeks before treatment to allow the fungus to grow within the wood. Replicates (usually four per treatment, treated one at a time) of each wood type were submerged in water and treated with HIUS with various combinations of impulse and total times, all at the highest intensity. Treatment times ranged from 30 to 60 minutes total, with impulse on/off times ranging from 30 seconds on and 30 seconds off to 600 seconds on and 120 seconds off. A total of 39 hickory blocks and 40 poplar blocks were treated. After treatment the blocks were surfaced sterilized by dipping in ethanol and flaming and then were aseptically placed on malt extract agar in glass jars and incubated. In all cases, visible fungal growth emerged from the HIUS-treated hickory (naturally infested) and pine (inoculated) blocks, indicating the HIUS had not killed the fungus in the wood.

Mold fungi test

Five mold species (*Aureobasidium pullulans, Aspergillus niger, Penicillium chrysogenum, P. fellutanum,* and *Trichoderma viride*) were grown in petri dishes. After the fungi had filled the plates, deionized water was added to the plate and stirred to dislodge the mycelia and spores from the surface of the agar. The spore and mycelium suspensions from all the plates were collected and mixed and then sprayed on pine sapwood 25-mm cubes. The samples were incubated for 3 to 12 days before treatment. The HIUS impulse treatment parameters were 10, 15, and 20 minutes on and 2, 2, and 4 minutes off. The total treatment time varied from 30 to 40 minutes, and 53 samples were treated in total. After HIUS treatment (three replicates), the samples were surfaced sterilized by dipping in ethanol and flaming and then were aseptically placed on malt extract agar in glass jars, incubated, and observed for fungal activity. After 2 to 5 days, growth of fungi could be seen on all samples.

Discussion

In their review, Piyasena et al. (2003) discuss some of the limitations of the application of ultrasound for disinfecting food products. They state that some organisms and life stages (e.g., spores) are relatively difficult to control with ultrasound and that the substrate can influence the efficacy of treatment. Wood, even very wet or freshly cut (''green'') wood, has air-filled cells and other voids. These voids, within the stiff wood matrix, are discontinuities in the liquid (water) medium that likely insulate the interior of the wood from the cavitation-inducing sound waves.

Ultrasonic treatments can have synergistic effects with heat, pressure and chemical treatments (US Department of Agriculture 2009). Thus treatments that incorporate HIUS with other processes (i.e., heat) and for products that do not require much penetration of the wood (i.e., used barrels), ultrasound may be a useful enhancement. However, as is the case with food products, HIUS does not appear to have the potential to be a stand-alone wood sterilization treatment.

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