EFFICACY OF RADIO FREQUENCY TREATMENT AGAINST SAPSTAIN AND WOOD DECAY FUNGI

Tubajika, K.M.[1], Janowiak, J.J.[2], Hoover, K.[3].
[1] USDA APHIS CPHST, Otis Pest Survey, Detection and Exclusion Laboratory, Otis ANGB, MA.
[2] Forest Resources Laboratory, Penn. State University, University Park, PA.
[3] Department of Entomology, Penn. State University, University Park, PA.

INTRODUCTION

Wood decay is of tremendous economic significance to the forest industry as well as other sectors of the US economy. Biodegradation of wood is accomplished in part by insects and marine borers, but the greatest degree of deterioration and product devaluation is caused by wood-inhabiting fungi. Solid wood packing material (SWPM) is recognized as a major pathway for introduction of insects and pathogens into the US on indigenous wood species. Currently, exported SWPM is disinfected using methyl bromide (MB) fumigation and conventional heat sterilization. Restrictions on MB use have increased interest in developing alternative treatments of SWPM. Radio frequency treatment may be an alternative which can reduce adverse thermal impact of treated commodities during heating period. The project reported here will evaluate the effectiveness of radio frequency for the control of wood decay and sapstain fungi in SWPM.

Materials and Methods

Wood block heating protocol. Wood used in all experiments were blocks of Red oak (*Quercus spp*), Poplar (*Populus alba* L.), and Southern yellow pine (*Pinus spp*) free of knots, visible concentration of resins, and showing no visible evidence of infection by mold, stain, or wood-destroying fungi (Table 1). Ten blocks of each wood species were chosen to test the heat uniformity and determine the heating rate required to reach the target temperature (60-70^{o}C) in an industrial 40 kW dielectric oven. During the RF heating, the wood block temperatures were monitored using 10 electrode fiber-optic probes (Canada). To position the probes in the wood, small holes were drilled and the probe was fit tightly in the wood to obtain a reliable seal. The moisture content (MC) was obtained from 21 wood blocks of each wood species. The initial weight was determined before RF treatment and was monitored daily to obtain constant MC. MC was calculated by dividing fresh weight by the total initial weight.

Wood tests. Wood blocks were infected with the following fungi: *Irpex lacteus, Geophyllium tracheum, Ceratocystis fimbriatat, and Ganoderma lucidum.* These fungi were chosen due to their status as, or similarity to, species of concern from the USDA pest risk assessment (USDA Forest Service, 1991). The fungi were grown on Potato dextrose agar (PDA) or Malt yeast extract agar (MYEA) at 25^{o}C for 10 days. Blocks were inoculated with the desired fungus by dipping a face of each 2-cm-deep into inoculum (10^5 spores/ml). Identical Red oak, Poplar, and Southern yellow pine wood blocks were left untreated as controls. Fungal colonization was visually assessed periodically. Ten wood blocks were considered as a replicate and the experiment was conducted twice. The experiment was carried out in a completely randomized design with three replicates.

RESULTS & DISCUSSION

Initial and preparatory experiments with 21 wood blocks of Red oak, Poplar, and Southern yellow pine used to test the uniformity of the electromagnetic field revealed that the center of the electromagnetic field was relatively uniform and that the temperature patterns after heating the wood block were reproducible. Wood blocks of different wood species were heated to a target temperature of 60^{o}C. MC of wood species had greater effect on the heating rate than uniformity in the electromagnetic field. In the experiment presented in Figure 1, the target temperature was 60^{o}C and the heating time was 2 min. It took a heating rate of 38.5^{o}C/min to heat Red oak, 29.6^{o}C/min for Poplar, and 22.1^{o}C/min for Southern pine. MC in wood blocks was 84.5% for Red oak, 80.5% for Poplar, and 14.5 % for Southern Pine (Table 2). The heating rate varied with wood species. It was high in wood with high MC (Red oak, 38.5^{o}C/min) and lower in Southern pine (22.1^{o}C/min). Heating rates were relatively low because of the low MC of wood blocks. For example, it was 22.1^{o}C/min in Southern pine with 14.5% of MC, and 38.5C/min for Red oak with 84.5% of moisture content (Table 2). MC loss was in the range of 76.4 to 98.4% for Red oak, 74.0 to 85.0% for Poplar, and 9.8 to 14.6% for Southern yellow pine. MC may be an important factor to consider with radio frequency treatments. These results demonstrate the importance of controlling the wood block MC to ensure uniform RF heating (Table 2).

Although there was a relationship between wood block MC and the heating rate of the wood, there was no relationship between MC and target temperature in all tested wood species (Figure 2). More than 5,000 isolations were made from 250 inoculated and control blocks. The evaluations showed that the fungi were recovered from 98% of the 30 non treated controls whereas none were recovered from RF-treated wood blocks. RF-treatment resulted in complete inhibition of the fungus when target temperature was applied (Table 3). The pathogen was recovered in less than 2% of RF-treated samples with high MC. In these samples the target temperature was not achieved.
RF treatment can, therefore, potentially provide an effective and rapid quarantine treatment as an alternative to MB fumigation for certain pathogen wood combinations. Additional research is sought to determine the effect of moisture content, temperature, and treatment durations on pathogen inhibition or destruction as well as treatment effects on other wood-inhabiting types of decay and sapstaining fungi.

Table 1. Wood species, wood size, and moisture content of wood exposed to Radio Frequency in an industrial 40 kW dielectric oven.

Wood species	Block size	Treatment	Total wood blocks	Moisture content (%)
Red oak	25x25x22	control	10	>100
		RF-treated	30	>100
Poplar	25x25x22	control	10	>100
		RF-treated	30	>100
Southern Pine	25x25x22	control	10	16.1
		RF-treated	30	16.1

Table 2. Moisture content of wood after heating and heating characteristics of wood blocks infected with sapstain and wood decay fungi.

Wood species	Treatment	Moisture[x] content (%)	Time[y] (min)	Heating rate C/sec	Power[z] (*Initial*)	Electrode height (cm)
Red oak	Control	89.1				
	RF-treated	84.6	1.27	38.5	0.84	20.3
Poplar	Control	83.2				
	RF-treated	80.5	2.28	29.6	0.69	24.1
Southern Pine	Control	14.8				
	RF-treated	14.8	2.15	22.1	0.69	11.4

[x]Final moisture content (%) after drying wood block in oven set at 60°C for 48 hr.
[y]Seconds to reach the target temperature.
[z]A = Amps.

.

Table 3. Percentage recovery of decay and sapstain fungi from wood surface after exposure to radio frequency at temperatures between 60-70°C in an industrial 40kW dielectric oven.

Wood species	Treatment	Percentage recovery *G. tracheum*	*I. lacteus*	*C. fimbriata*	*G. lucidum*
Red oak	Control	100	100	99	100
	RF-treated	3	2	1	3
Poplar	Control	99	100	100	99
	RF-treated	0	0	0	0
Southern Pine	Control	99	100	100	100
	RF-treated	0	0	0	0

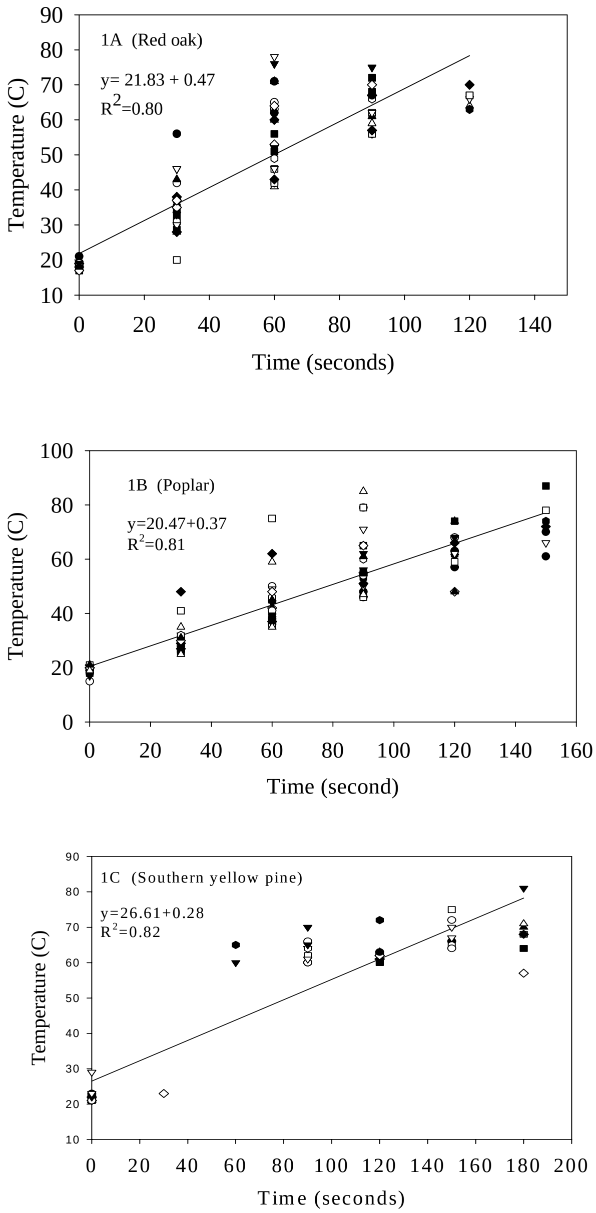

Figure 1. Time to heat a wood block of Red Oak (A), Poplar (B), and Southern yellow pine (C) to 60 and 70°C with radio frequency energy. Temperatures were monitored.

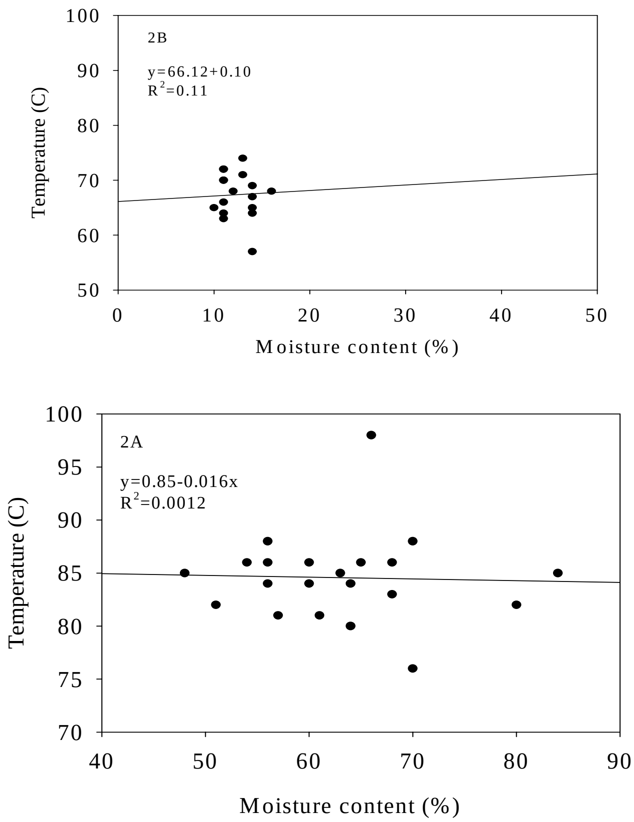

Figure 2. Relationship between temperature and moisture content of Red oak (A) and Southern yellow pine (B).