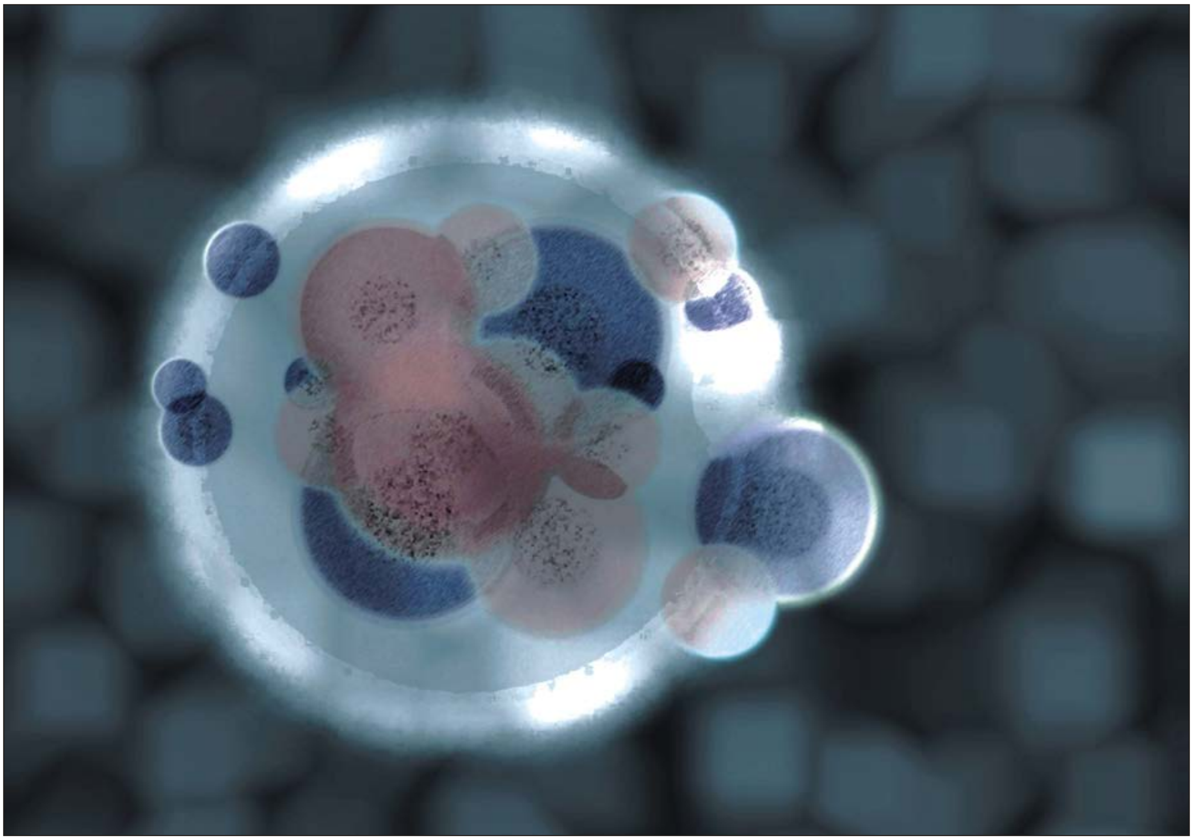

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 7 (8): 1463-1467, 2007
ISSN 1727-3048

Impregnation of Beech, Maple, Alder and Lime Under Different Treatments of Extractives and Fungal Attack

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Abstract: Impregnation of some commercial woods in North of Iran were carried out by using different treatment. Wood extractives of Ash (*Fraxinus excelsior*), Elm (*Zelkova carpinifolia*), Oak (*Quercus castanifolia*) and Mulberry (*Morus alba*) were taken and essences of Rose flowers (*Rosa damascene*) and Fumitory leaves (*Fumaria* sp.) were extracted. Wood blocks measuring 0.5×1×5 cm of beech (*Fagus orientalis*), maple (*Acer insgin*), alder (*Alnus subcordata*) and lime (*Tilia* sp.) were impregnated by extractives. A part of wood samples were chipped and milled, by using Tappi (T20403-76) standard. The Rainbow fungus (*Trametes versicolor*) was selected from forest and prepared in laboratory. All treated and untreated wood blocks oven dried, cooled, sterilized and exposed to the fungus. Results showed that extractive materials are in different concentrations and different classifications by impregnation process. Mulberry extractive with low penetrable class caused the weight losses in all wood species to be decreased.

Key words: Impregnation, wood species, extractives, weight loss, rainbow fungus

INTRODUCTION

Wood is impregnated injecting certain chemical products (liquids), which can be done by immersion, vacuum immersion and vacuum-pressure. Some natural resin and the extractives from the heartwood of a durable wood species may improve the properties of wood and can be used as a wood preservative (Nogueira *et al*., 2002). However, wood species have different behaviors when are impregnated with preservatives, as sapwood of Scots pine gives the best results for penetration with copper azole (Yildiz, 2007). Also heartwood of Scots pine may exhibit some difficulties in impregnation (Rhatigan *et al*., 2004). Some wood species absorb very little preservative even when treated by vacuum pressure impregnation. They are classified as refractory species which means sapwood and heartwood are both difficult to treat with preservative solutions (Ilker Ustal *et al*., 2006). On the other hand, bordered pit membrane in some cells of wood species closes in the heartwood and makes it difficult to impregnate the wood preservatives to purpose of production of high value-added wood. Some techniques like underwater shock wave can treat the pre-dried wood for the penetration improvement (Shigeru *et al*., 2006). The acceptance criterion which covers a wood impregnation system is using monomer and chemical impregnation technique (ICC, 2005). Measurements of impregnation in different wood species with various preservatives and suitable retentions (kg m^{-3}) under different conditions can help workers to protect woods against any microorganisms. In North forests of Iran the famous fungus which attacks many of logs called *Trametes versicolor*. Fungal mycelium utilizes the sapwood in all wood species. In Iran, except some partial wood species like oak, elm, walnut and mulberry, which have high natural extractives in heartwoods and resistant to fungal attacks, other wood species similar to hornbeam, beech, alder, maple, etc., are usually perishable. Therefore, protecting non durable species by using different methods for impregnations of preservatives against destructing factors since the time of logging to the level of using in services is necessary. Nowadays creosote, pentachlorophenol, CCA and ACC as wood preservatives are used in different services (indoor and outdoor). Wood treated with useful preservatives generally protect woods against fungi and insects for many years (Eaton and Hale, 1993). However, many of preservatives are not persistent to water, when treated products exposed to washing. Some materials are washed into ground and environmental problems will be occurred. As a result some preservatives like CCA may be hazardous to environment and are not allowed to use (Lebow and Tippie, 2001). Therefore the aim of study, is finding new natural and safe preservatives with minimum risks. Also measurement of impregnation rates of wood and penetrations of extractives into wood species are searched.

MATERIALS AND METHODS

Trees of oak, ash, mulberry and elm were harvested at Sari forests in 2003. Then logs were cut to lumbers and small wood block. A part of above samples were chipped, milled, filtered by mesh (0.5-1 mm), oven dried at 100±2°C and weighed. Extraction was conducted on a soxhlet apparatus made up of extractors, round bottom flasks setting on electrical heaters containing solvent (acetone) by using T20403-76 standard. For taking essences of rose flowers and fumitory leaves, methanol solvent was applied. Then all extractives with different concentrations were conducted on desiccators apparatus connected to a vacuum pump. During 15 min negative atmospheric pressure (-0.8 atm) transferred soluble extractives into wood samples measuring 0.5×1×5 cm. At the end of impregnation process all treated wood blocks were weighed and oven dried at 50°C. Two grams of wood powders (with and without extractives) were poured into small Pyrex tubes, oven dried, cooled, weighed and sterilized. All tubes containing wood powders were transferred on fungal grown mycelium in 90 mm Petri dishes. After 6 weeks incubation, wood powders oven dried, cooled and weighed and weight losses of wood powders were calculated.

Trametes versicolor a white rot fungus that is used in standard methods (EN 113, 1994) as representative of Basidiomycete fungi for testing of hardwood durability. This fungus is a destructing factor for logs after felling. It was taken from Darabkola forest in Mazandaran province (Fig. 1, 2). It was cultured on Malt extract agar, then wood blocks (treated and untreated) and Pyrex tubes containing wood powder transferred on the grown mycelium. All Petri dishes maintained at 22°C and 70% humidity for 6 week. At the end of the experiment mycelium were furbished from surfaces of wood specimens. All wood samples and wood powders were oven dried, cooled and weighed. Finally weight losses were measured and all data analyzed by SAS and regressions methods.

Fig. 1: Rainbow fungus (*Trametes versicolor*) in Darabkola of Sari forests

Fig. 2: Beech log attacked by Rainbow fungus in Darabkola of Sari forests

RESULTS

In extraction process a fix amount of solution and time are used. At the end of extractions several extractives with different colors and concentrations were obtained. The first data was related to concentration of extractive solutions and they were as follows: Oak, 0.53%, Elm, 0.54%, Mulberry, 0.95% and Ash 0.49%. For Rose and Fumitory essences different concentrations with 9.36 and 5.73% were, respectively calculated. As data shows there are significant differences in concentrations of extractives and therefore, the rate of concentrations could not be already determined. The rate of extractive retentions (kg m^{-3}) and percentages of impregnations which were injected as liquid in wood species were differently achieved. The lowest impregnation rate of extractives related to mulberry and the highest to methanol solvent. Results indicated that different extractives with different concentrations have various behaviors when they are injected into wood blocks. Also as the density decreased, the structure of wood species caused changes to the rate of extractives impregnations (Table 1).

High concentration of mulberry extractive among the other wood extractives (oak, elm and ash) caused to obtain the lowest impregnation in woods (beech, maple, alder and lime). While extracted materials from flowers and leaves (rose and fumitory) with very high concentrations were not able to make the lowest impregnations in wood species. However, the rate of extractives injected (impregnations) into wood samples are classified into four groups which are shown in Table 2.

Results concerning wood powders testing exposed to fungal attack showed that samples of mulberry powders (with extractives) after 6 weeks incubations had the lowest weight loss. While, the highest weight loss was related to elm powders. Analysis of results indicated that there is significant difference between weight losses obtained from mulberry and elm (Table 3).

Table 1: Impregnations% and retentions (kg m^{-3}) in wood samples

Type of preservatives	Beech	Maple	Alder	Lime	Total means (%)
Oak	38.01	48.99	67.71	90.68	61.34
Elm	60.27	50.85	70.04	110.04	72.80
Mulberry	27.30	33.16	40.18	69.15	42.44
Ash	38.86	45.82	98.55	75.16	64.59
Rose	53.22	55.18	116.21	103.23	81.96
Fumitory	55.97	43.38	98.15	85.31	70.70
Acetone	61.84	51.83	110.66	94.69	79.75
Methanol	57.28	54.23	100.82	135.71	85.67
MI %	49.09	47.93	87.78	109.13	-
MR (kg m^{-3})	2.01	2.55	3.58	4.77	-

(MI %) Mean value of Impregnations % and (MR) Mean value of Oak Retentions (kg m^{-3})

Table 2: Classifications of extractives impregnation rates into wood species

Type of class	Kind of extractives	Kind of impregnation (%)
1	Acetone, methanol and rose essence	Highly penetrable
2	Elm and fumitory extractives	Penetrable
3	Oak and ash extractives	Mid. penetrable
4	Mulberry extractives	Low penetrable

Table 3: Weight losses in powders of woods which extracted after 6 weeks by *Trametes versicolor*

Type of Ext.	Ext. (%)	WL with Ext.	WL without Ext.
Oak	8.37	32.79	54.04
Elm	7.80	56.51	51.78
Mulb.	7.32	26.93	45.59
Ash	4.76	35.48	39.62

Mean of Extractives (Ext), Mean of Weight Loss (WL) and Mulberry (Mulb)

Table 4: Mean weight losses of wood samples exposed to *T. versicolor*

Extractives	Beech	Maple	Alder	Lime	Means (%)
Oak	30.61	29.43	36.09	20.47	29.15
Elm	26.62	34.11	27.97	29.43	29.53
Mulberry	20.22	25.51	32.15	20.86	24.68
Ash	27.93	25.50	34.61	30.78	29.70
Acetone	27.97	37.99	24.95	30.25	30.29
Rose	29.60	41.60	31.49	37.14	34.82
Fumitory	34.38	28.30	23.23	31.74	29.43
Methanol	26.85	26.14	24.23	28.54	26.44
Control	35.75	37.35	31.20	20.76	31.26
Total means (%)	28.02	31.00	29.35	28.65	-

When wood powders (with extractives) exposed to *Trametes versicolor*, all the weight losses decreased except elm. Results due to elm powders weigh losses showed that there are differences between wood powder and sound wood properties in contact with fungal deterioration. Sound wood of elm (*Zelkova carpinifolia*) in same condition has high resistant to *T. versicolor*, therefore the wood blocks are very durable against fungal attack (Kazemi *et al.*, 2003).

Very low concentrations of extractives could not affect the protection of treated wood. While among all extractives, mulberry was most effective on wood durability. In classification of impregnation rates mulberry was also in low penetrable class (Table 4).

Relationship between weight losses and impregnations of wood samples using regression,

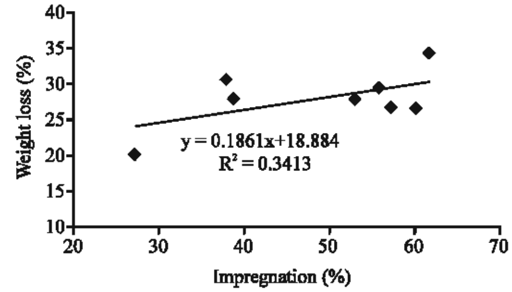

Fig. 3: Relationship between weight losses and impregnation in beech

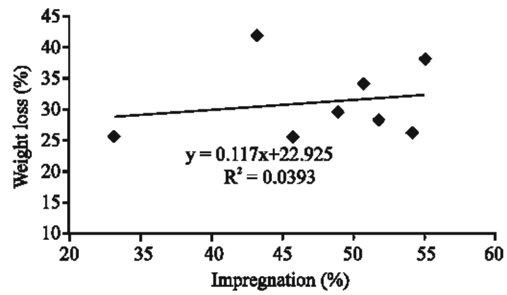

Fig. 4: Relationship between weight losses and impregnation in maple

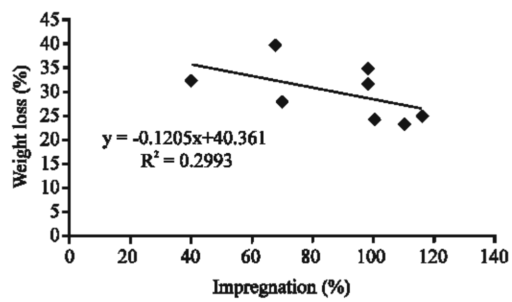

Fig. 5: Relationship between weight loss and impregnation in alder

demonstrated that wood species have different characters and behaviors when exposed to fungal attack and various extractives. The lowest weight loss was related to mulberry due to extractive effects on wood durability and the highest concentration of wood extractives was also associated to mulberry. The results indicate that other negative linear growth is due to increase in extractive concentrations and decrease in wood decay. As the density of wood is not a major factor of wood resistance to decay; many wood species with high density are also susceptible to fungal attack, therefore obtained relationships between impregnations and weight losses were not significant. On the other hand, other important

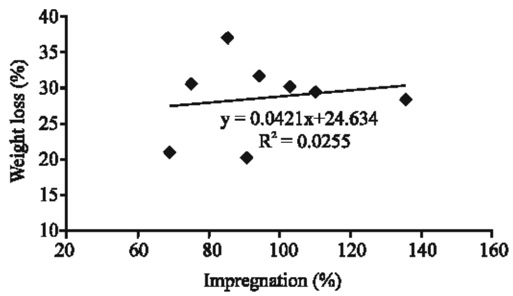

Fig. 6: Relationship between weight loss and impregnation in lime

factors like high extractives, resins and silica in wood species may be the major factors in wood resistance against microorganism's risks. Results also revealed that impregnation increase in wood blocks causes increase in weight losses, especially in beech. But in the alder case, the linear relationship is negative, which means any increase in impregnations causes decrease in weight losses (Fig. 3, 4, 5, 6).

DISCUSSION

The properties of wood penetration and its effects on fungi have been reported by some workers (Yildiz, 2007; Morris *et al*., 2002). However, from data obtained using regression, we can include this fact that in all wood species except alder, a positive relationship between impregnation and weight loss is presented. Thus with impregnation increase, the weight loss was also increased. In another word, alder is called as water resistant; therefore the result is in agreement with previous report about alder resistance to water permeability (Kazemi, 2006). Increase in wood extractives concentrations can decrease wood decay, as data given in extractives of Mulberry. But other results indicate that molecule constructions of extractives in various species are different and increase in extractives concentration is not the main factor to prevent microorganism's attack i.e., interactions between many factors may cause some effects on protection of wood hazards. In the case of flowers and leaves; extractives and their affect on wood decay process, the result is not reasonable. The nature of preservative may affect the rate of solvent's penetration into wood structures, size of molecules in extractive's components and the kind of liquid bonds connected to cell walls, as it can also play an important role in wood sample's penetration rate. As increase in heartwood extractives generally rises wood durability at all wood species (Kazemi *et al*., 2003), the effect of extractives could be more important than impregnation. The impregnation results indicate that the type of wood structure (density and porosity) is not a main factor in wood deterioration. Also it seems that there is a minor effect and negative relationship between wood porosity (more penetration) and wood durability. Nevertheless, the type of extractive molecules as natural materials may prevent water flow into vessel elements; therefore, the lack water presents undesirable condition for fungal attack. As a result, high extractives in heartwood prevent suitable conditions for microorganism's activity.

ACKNOWLEDGMENTS

All thanks are given to Research Institute of Forest and Rangelands of Iran where financially supported this research and also thanks to Dr. Jalily, Dr. Rezaii, Dr. Ahmadi, Mr. Arabtabar, Mrs. Mehraban and Miss A. Kazemi who accompanied this study.

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