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THE EFFECT OF A PEG TREATMENT ON DIFFERENT WOOD SPECIES

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Abstract:
The present research derived from the necessity to make furniture from small round wood (different wood species were considered) and a serious problem of wood cracking occurred when green wood is dried. Experiments were focussed on the PEG 4000 treatment, in low concentration in water, for two types of wooden samples: round slices and small prismatic samples. The results are satisfactory for round wood, indicating a smaller incidence of the cracks after drying for PEG treated wood than untreated samples. The efficiency of PEG treatment on prismatic samples exposed to a water immersion test (1, 2, 3, 24, 48, 72 hours) revealed a lower level of water absorption for PEG treated samples than untreated. The dimensional changes in R and T directions were no significantly improved. There are some improvements for PEG treated wood, but after 24h of immersion the swelling of treated samples increased and tend to exceed the values for untreated. More research and more investigation methods will be required to demonstrate the efficacy of treatment.

Key words: *PEG treatment; dimensional stability; water absorption; swelling; wood species.*

INTRODUCTION

A permanent challenge for wood industry sector is the responsible wood utilisation, that requires an efficient industrial process (Cartwright 2008) and, consequently, a better knowledge of its properties. In Romania and other parts of the world there is a growing demand for recycled solid wood or for traditionally, rustic constructions made from round wood. The demand is also for hardwood and softwood furniture, flooring and other products. Many interior and furniture applications today use the natural aspects of wooden materials as a sales advantage (Nilsson 2015). The round wood, even small-diameter category, is used especially for small objects, rustic decoration or small structures in exterior environment. The exposure of wood to a natural drying process causes its shrinkage, cracking and irreversible deformation. As result, the competitiveness of wood as an engineering material in different application fields is diminished (Meints et al. 2018).

A series of international experiments revealed that timber treatment by polyethylene glycol (PEG), also known as Carbowax (the tradename for PEG produced by Union Carbide in 1940), is a good alternative to improve the quality of wood, especially dimensional instability (Stamm 1959, Ralph 2006). It is non-toxic (incorporated in food and cosmetics), water-soluble, can be used at room temperature. Previous international experiences have shown that PEG with different molecular weight have been used as bulking agent by completely replacing the water in the swollen cell walls. Polyethylene glycol -1000 was one of the most used variant (Stamm 1959, Rowell 1987). It has been heavily researched for its commercial applications as a stabiliser for green wood and it has remained the most widely employed chemical by conservators of archaeological wood (Rowell 1987, Howlett 1988). It diffuses into the deteriorated wood, supporting and keeping it intact during drying. This is a common problem in the conservation of waterlogged wood that is solved through the use of different PEG solutions (400 and 4000) (Saeterhaug 2001). PEG 4000 is also used in different concentrations and by various procedures for waterlogged wood, but some researches were unsatisfactory (Unger et al. 2001).

The most significant draw backs to using PEG were the cost of the chemical, treatment time required (days, months, even years) and the hygroscopicity of the compound. PEG has become a contemporary chemical for timber hobbyists and use in small- and large-scale timber preservation (Ralph 2006).

The present research started from the necessity to make furniture from small round wood (different wood species were considered) and a serious problem of wood cracking occurred when green wood is dried.

OBJECTIVE

The present experiments were focussed on the following objectives:

- To identify some opportunities for a simple treatment of green round wood (to be used for furniture) to avoid the checking occurrence during the drying process and
- To evaluate the effect of PEG (polyethylene glycol) treatment on the dimensional instability of some wood species and its efficiency

METHODOLOGY

A freshly cut green wood was used for research. The wood species were diverse and were selected as commonly used species or less valuable species, with potential for furniture manufacturing: pine *(Pinus sylvestris*), spuce (*Picea abies*), beech (*Fagus sylvatica*), oak (*Quercus robur*), black alder (*Alnus glutinosa*), hornbeam (*Carpinus betulus*) and poplar (*Populus spp.*)

Two types of wooden samples were processed for experiments:

- Round wood slices of 2cm in thickness, 1 sample/species/test. Each sample was cut in three parts: one third for moisture content determination, one third for PEG treatment and the last as control, untreated.
- Small prismatic samples of (25x25x20) mm, corresponding to wood growing directions (RxTxL), with parallel faces and without defects, 5-7 samples/species/test.

A set of samples (both round and prismatic samples) were previously weighed and oven dried gradually following a slow drying schedule: 30°C for 3 hours, 50°C for 3 hours and finally at (103±2)°C and the initial moisture content was determined.

The second set of wet samples was treated in a 4% solution (by weight) of PEG 4000 in water. The moist wood was immersed in PEG solution for a period of 7 days at 20°C. In order to determine the impregnation rate (G, %), before and after treatment the samples were weighted (the initial mass M_i and mass after treatment M_t were determined) and then were dried according to the same slow regime as the samples for moisture control. G was calculated according to formula below:

$$G = 100x\ (M_t\text{-}M_i)/Mi,\ \% \qquad (1)$$

where: Mt- the mass of wood after treatment, in g; Mi- the initial mass of the sample, at initial MC, g.

The round wood was used to highlight the effect of PEG treatment for green wood stabilisation, to keep it from cracking or splitting, respectively. The small samples were used to determine the effect of PEG treatment on the dimensional stability. As result, in parallel, the untreated (reference) and treated samples were exposed to a test of water immersion for a period of 1, 2, 3, 24, 48, 72, hours. After each interval of time the samples were weighted to determine the water absorption in wood (WA) and measured in radial and tangential directions, in 5 points on the measuring directions, in order to determine the swelling coefficients.

RESULTS AND DISCUSSION

The experimental results are discussed for two types of samples and tests. The initial moisture content of the seven species tested in this research is presented in Table 1. The origin of both types of woods was not the same, as result the initial MC for pine and alder was higher than round wood.

Table 1

Initial MC (%) of the tested wood

Wood species	Pine	Spruce	Beech	Oak	Black alder	Hornbeam	Poplar
Round wood slices	48.76	70.59	67.22	48.04	67.28	49.71	72.57
Small prismatic samples	102.93	72.98	70.89	52.12	100.43	44.32	60.29

First test of oven dried slices revealed a smaller incidence of cracks in PEG treated wood than untreated samples. The visual assessment indicates visible improvements illustrated by the images from figures below (Fig.1). Moreover, after PEG treatment and slow drying process beech, oak, and alder have no visible checks on the surface. Only hornbeam presented some smaller, superficially checks towards the pith of wood. The density of wood species is very important in relation with moisture content and shrinkage phenomenon. As result, for pine, spruce and poplar no changes are visible neither on the untreated samples nor on the treated ones.

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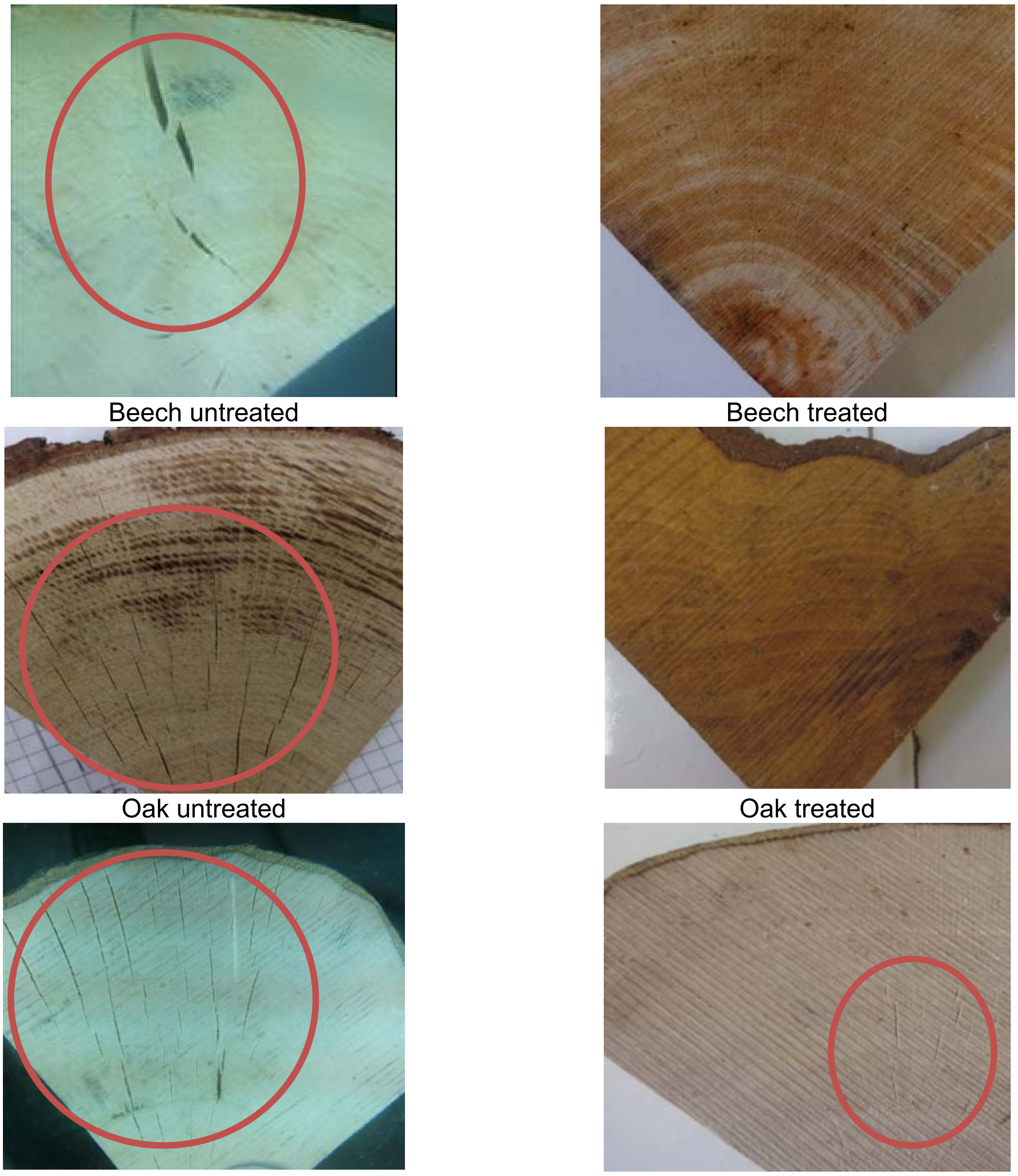

Beech untreated | Beech treated

Oak untreated | Oak treated

Hornbeam untreated | Hornbeam treated

Fig. 1.
The effect of PEG treatment on cracking phenomenon after drying (untreated vs. treated samples; red marks indicate cracks or checks in wood).

Therefore, the performance of treatment depends upon a number of factors, such as the anatomy of wood, density, the moisture content, thickness of the specimens.

In the second test the impregnation rate calculated as solution uptake (%) is given in graph from Fig. 2.

The great PEG absorption for spruce could be explained by the large proportion of early wood and the presence of large-diameter anatomic elements which provide flow of impregnation liquid. Spruce and poplar absorbed a consistent quantity of solution in relationship with their smaller density (>25% in poplar and >35% in spruce).

In some cases, the moisture content facilitated the movement of PEG solution into the wood and the impregnation rate (alder). For other species (beech, oak, hornbeam) the absorption was limited by wood structure.

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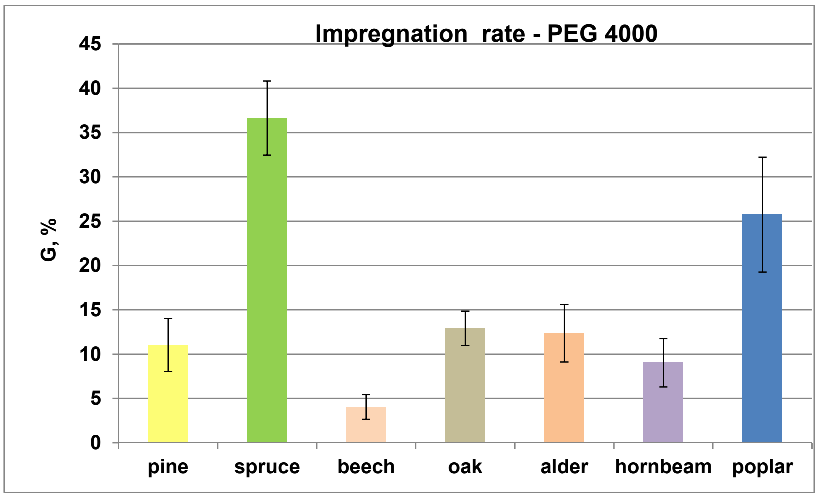

Fig. 2.
The impregnation rate of PEG 4000 calculated as percent of solution uptake.

The water immersion tests revealed a lower level of water absorption for PEG treated samples than untreated (Fig. 3).

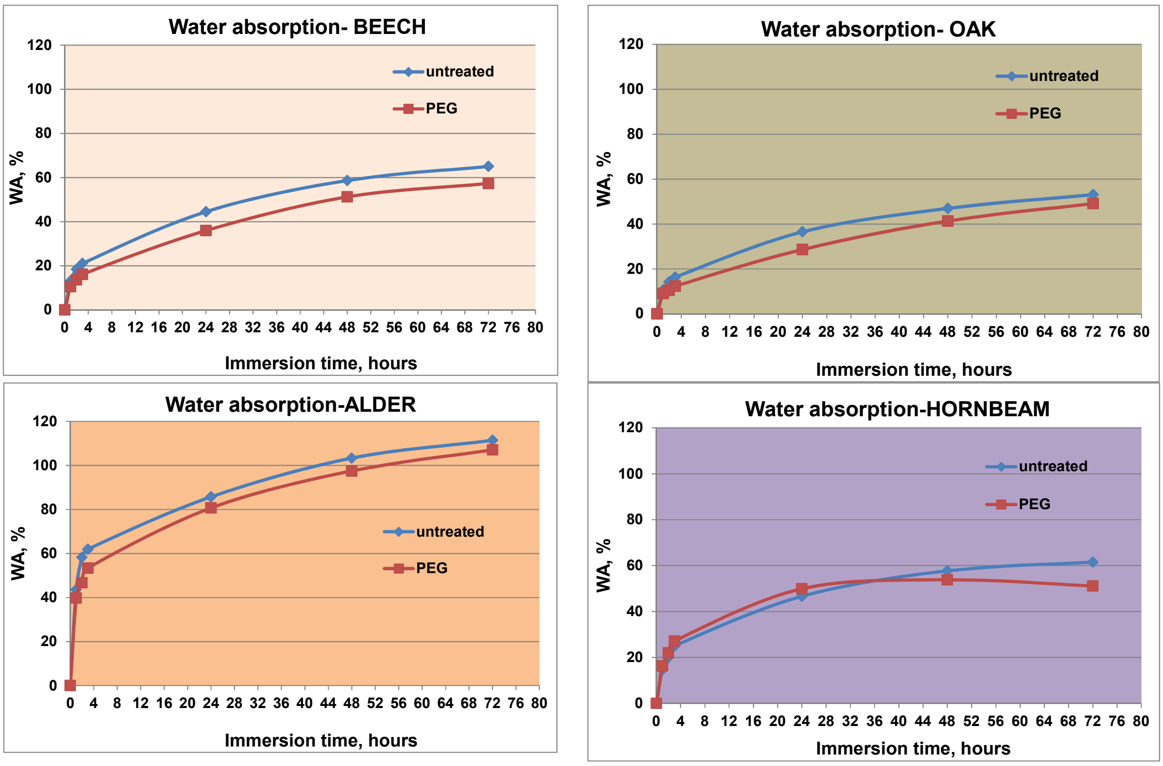

Fig. 3.
The water absorption diagrams for the tested wood species (spruce is not presented), untreated vs. PEG treated.

In this situation, a reduction with 26% to 3.5% of water absorption for treated samples, according to the wood species and testing time were obtained. Nevertheless, with time immersion increasing the effect of PEG treatment is reduced and WA for PEG treated samples tend to attain the values of WA for untreated samples. An example of water absorption diagrams, and the corresponding swelling evolution is presented for pine and poplar wood (Fig.4). The dimensional changes in R and T directions were no significantly improved. As seen in Fig. 4, there are some improvements for PEG treated wood, but after 24h of immersion the swelling for treated samples increased and tend to exceed the values for untreated. Moreover, PEG remains water soluble. As Rowell concluded (1987), PEG is not fixed in the wood and in contact with water it will start to leach out. Some research found swelling values (e.g. for PEG 1000) impregnated pine independent on the wood moisture content before (Meints et al. 2018). These conclusions are confirmed by the present results. The moisture content before treatment was 102% for pine and 60% for poplar. The evolution and the value of WA are quite different for these species, as seen in Fig 4.

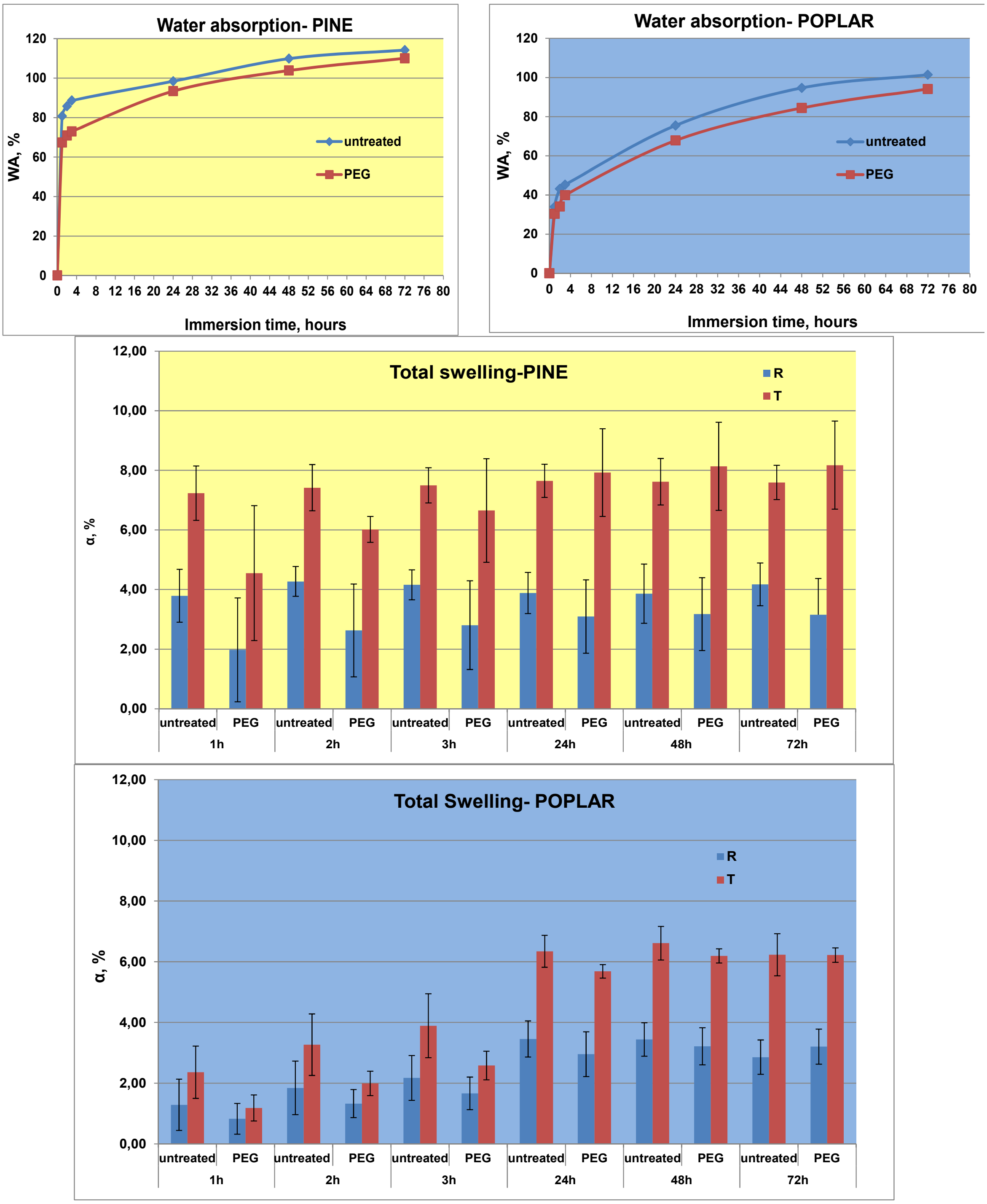

Fig. 4.
Water behaviour - an example for pine (IMC=102%) and poplar (IMC=60%), untreated vs PEG treated wood.

Considering a recent study, Meints (2018) recommended use of lower molecular weight PEG (<1000), for an efficient impregnation. In the present research the high molecular weight of PEG and its low concentration possibly did not lead to an optimal impregnation to penetrate the cell wall. Moreover, PEG 4000 is less hygroscopic, but its large molecules difficult penetrate the dense wood. http://nautarch.tamu.edu/CRL/conservationmanual/File6.htm. In accordance with Ralph research (2006), the different wood structure of species used in experiments could minimise the impregnation.

CONCLUSIONS

The present research demonstrated the limits of PEG 4000 impregnation in low concentration for improving of dimensional instability. The treatment efficiency is not so evident because of leachability of PEG in water. More research and more investigation methods will be required to demonstrate the efficacy of treatment. Encouraging results were obtained for round wood treated with PEG, but it could have a temporary modification of wood properties while drying green wood (Ralph 2006). Low molecular weight PEG (<1000) could be an useful aid to the practice of furniture conservation (Howlett 1988), for treatment of panel paintings or other wood curved panels. In addition, PEG treatment is recommended especially for timber with high dimensional stability requirements, only when necessary and not for indoor use (Mitchell 1972).

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Using the Two-Step Method

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