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HYGROSCOPIC PROPERTIES AFTER WEATHERING OF SOME VARNISH COATED WOOD SPECIES

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Abstract:
Eight different wood species (Juglans regia, Paulownia tomentosa, Acer spp., Querqus, Larix decidua, Niangon, Tilia cordata, Fraxinus excelsior) have been subjected to artificial weathering from 0 to 600h. The long term artificial weathering experiment was performed in order to examine the resistance to weathering regarding dimensional stability and absorption of various wood species coated with water-soluble varnish and uncoated (control samples). Samples were prepared in tangential, radial and longitudinal grain orientations from the above species. The eight wood species studied showed, however, differences in their response to artificial weathering conditions. According to the results obtained from the coated and uncoated samples, better wood stability would be certainly achieved by coated samples.

Key words: *artificial weathering; absorption; dimensional stability; wood; varnish.*

INTRODUCTION

When wood is revealed to outdoor conditions, a multiplex mixture of chemical, mechanical and energy factors contribute to what is reported as a weathering. The exposure to ultraviolet (UV) irradiation and moisture are the basic circumstances of wood weathering. Wood degradation is demonstrated by color change, followed by, roughening and sometimes by checking. The alteration of wood color is however to be as a result of the UV light which acts in cooperation with moisture, temperature, and oxygen and/or ozone to depolymerize lignin and cellulose in wood cell wall (Anderson et al. 1991). The depolymerization of lignin and cellulose also lead to decrease in some physical, chemical and biological properties of wood. The weathering influences mainly the wood surface and significantly eliminates the aesthetic appearance and efficiency of wood. Sunlight converts the wood color to grey at the beginning of the exposure period, and then the surface fibres are detached upon prolonged exposure owing to depolymerisation of lignin and carbohydrates in the cell walls. In addition to color changes, mildew growth, checking, splitting, and warping take place on the wood surfaces (Teacă et al. 2013; Temiz et al. 2009).

Consequently, wood should be protected by various preservatives. Wooden material should be preserved to improve its durability against outdoor conditions. It is been well known that the most familiar method is to coat surfaces of wooden materials with different lacquer layers to protect them against weathering conditions. Water-based finishes are made up of droplets of solvent-based finish, usually acrylic or polyurethane, and a solvent, usually glycol ether, with water functioning as a thinner. Water-based finishes may raise the wood grain and offer only moderate resistance to water, heat, and solvents (Çakıcıer et al. 2011; Sonmez and Budakçı 2004).

Coatings can be degraded under the weathering procedure such as sunlight, temperature, oxygen, water and pollutants, which can deteriorate wood's properties. The service life of a coating rely on the environmental conditions, the properties of the coating, and is associated with the moisture content of wood, photochemical and microbiological degradation occurred by blue stain and mould fungi. The protection competence also depends on the darkness of the coating. Among these factors, UV irradiation is the major contributor to degradation. In order to evaluate coating service life in a short term, different accelerated ageing tests are carried out by simulated solar irradiation, temperature, moisture in natural environment (Ozgenc et al. 2012).

The solid color stains and paints have longer service life than transparent ones. This may happens due to the fact that clear or transparent finishes do not have pigments to absorb the UV rays, thus, the UV can pass through the clear coating layer and cause oxidation of lignin. Lignin degradation contributes to raised water uptake and defibrillation of cellulose fibres from the wood surface. Thus, if we can find a good way to prevent lignin degradation, for instance by having high pigment concentration or other UV absorbers, then the coating will last longer (Williams 2010).

Swelling and shrinking of wood also influences the reliability of those wood constructions that must have a high dimensional stability for good performance. Thus, the dimensional stabilization of wood in these situations would improve their long-term durability in exterior exposures. Weathering provokes reduction of hydrophobicity of the wood surface via a variety of chemical and structural alterations (Kishino and Nakano 2004). Exposure to UV causes photodegradation of lignin and the formation of a cellulose hydrophilic surface. Although photodegradation is primarily external, moisture-induced checking may extend to depths of several millimeters (Evans et al. 1993) and can work as pathways for water into the wood subsurface. Most of the photodegradation and checking takes place within weeks of exposure, but can go on for at least 6–12 months before proceeding to continuous erosion (Evans 2012; Kalnins and Feist 1993).

OBJECTIVE

The objective of this study was to investigate the changes caused by weathering on some wood species coated with water soluble-varnish. Hygroscopic properties of wood species were investigated after several intervals (0-600 h). Accelerated weathering using UV irradiation and water spray was used to simulate natural conditions in multi-year cycles according to the method described in standard EN ISO 11341:2004.

MATERIAL, METHOD, EQUIPMENT

Wood material

Eight different species of wood (5 of each specie), Juglans regia, Paulownia tomentosa, Acer spp., Querqus, Larix decidua, Niangon, Tilia cordata, Fraxinus excelsior, were used for the experiments. Samples with dimensions of 50 mm by 50 mm by 10 mm were conditioned in a climate room having a relative humidity of 65% and a temperature of 20^{o}C until they reach equilibrium moisture content of 11%. All samples of each species were cut from the same air-dried board to ensure high homogeneity.

Artificial weathering was carried out according to the European standard EN ISO 11341 equipped with a filtered xenon-arc UV lamp for 2000 h (5 cycles). The test was carried out for coated with varnish and uncoated samples for 0- 600h. The duration of each wetting cycle test was 120 min where 18 min was the wetting time and the 102 min was the dry period (Relative humidity 40-60 %).

Dimensional stability Measurements

The changes of coated with varnish and uncoated specimen's water absorption and dimensions changes of (Tangential, Radial and longitudinal) directions were measured before and after artificial weathering in the same location each time. The measurements took place in various weathering duration (0, 24h, 48h, 72h, 96h, 120h, 172h, 316h, 388h, 532h).

RESULTS AND DISCUSSION

Figures 1 to 16 depict the periodical rate of water absorption and dimensional stability of wood species after artificial weathering for different exposure times.

Water absorption of *Juglans regia* was gradually decreased until the end of the weathering test. Comparing coated and uncoated samples it is obvious that coated specimens show much better results as regards dimensional stability and absorption. As concerns dimension changes, tangential direction presents more intense changes than radial and longitudinal direction.

The same phenomenon was noticed at *Paulownia tomentosa* samples. The water absorption of coated samples was significantly lower than uncoated specimens. The higher reduction of water absorption was observed at 316h weathering. Associating the results of all (eight) wood species above and below, *Paulonia tomentosa* display the major absorption and dimensional change reduction.

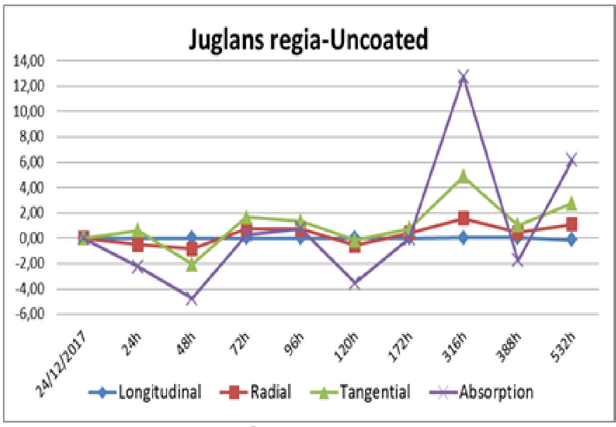

Fig. 1.
Absorption-dimension changes of Uncoated Juglans regia.

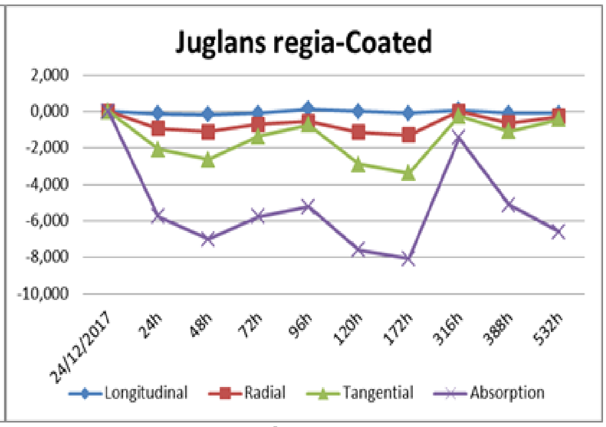

Fig. 2.
Absorption-dimension changes of Coated Juglans regia.

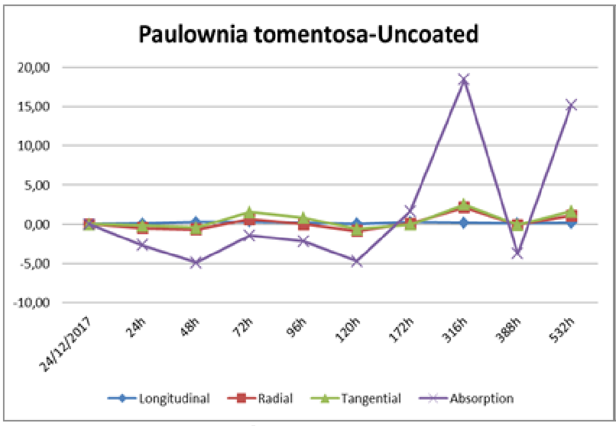

Fig. 3.
Absorption-dimension changes of Uncoated Paulownia tomentosa.

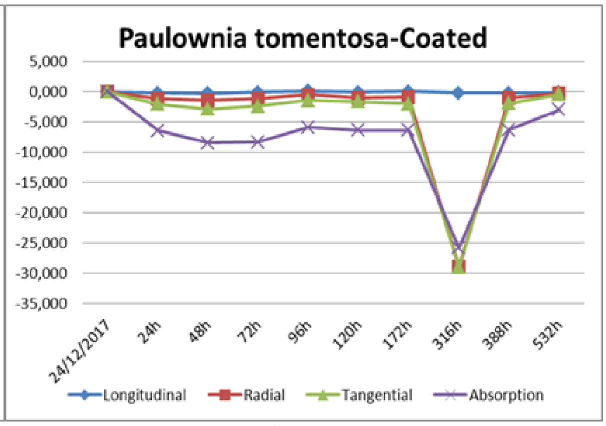

Fig. 4.
Absorption-dimension changes of Coated Paulownia tomentosa.

Uncoated samples of *Acer sempervirens* exhibit great increase of water absorption, effect that is in contrast to coated samples which gave an adequate decrease. Longitudinal direction of all wood species shows faint changes comparing to tangential and radial directions.

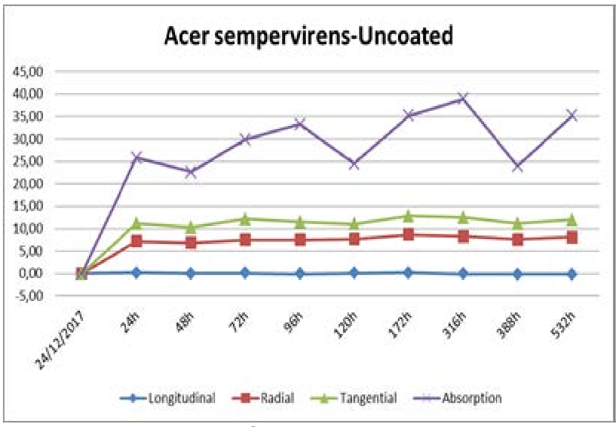

Fig. 5.
Absorption-dimension changes of Uncoated Acer sempervirens.

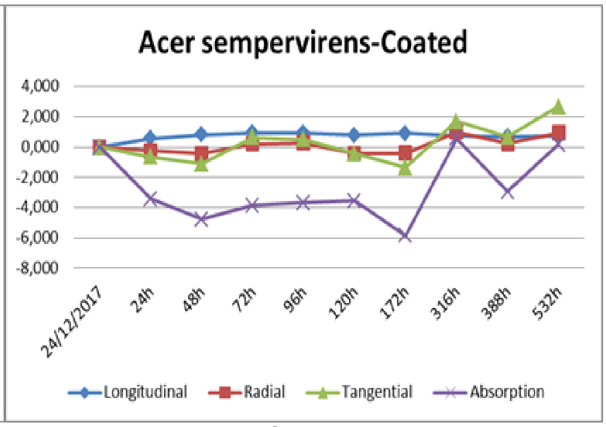

Fig. 6.
Absorption-dimension changes of Coated Acer sempervirens.

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The same effect as uncoated Acer sempervirens observed at *Querqus alba* samples. On the contrary, the dimension changes and absorption of coated samples were enhanced at the initial weathering time (till 72h).

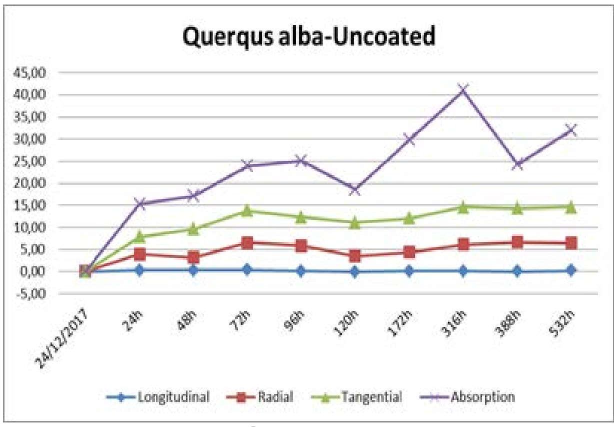

Fig. 7.
Absorption-dimension changes of Uncoated Querqus alba.

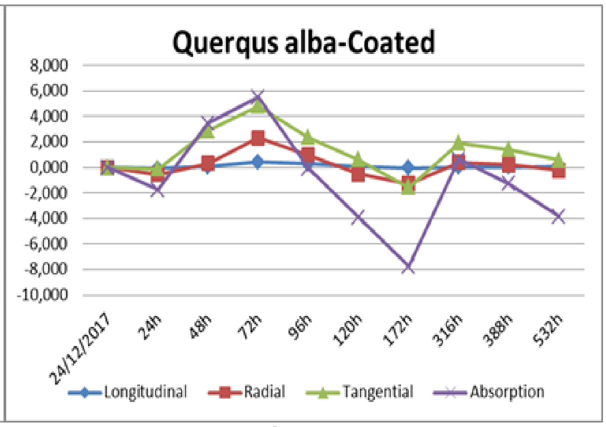

Fig. 8.
Absorption-dimension changes of Coated Querqus alba.

Weathering conditions of uncoated *Larix decidua* samples did not influenced in great extend as other wood species. On the other hand, coated samples showed decrease.

Tarrieta utilis samples both uncoated and coated present reduction in water absorption and dimension changes. Additionally, the reduction fluctuate during the test in great extent.

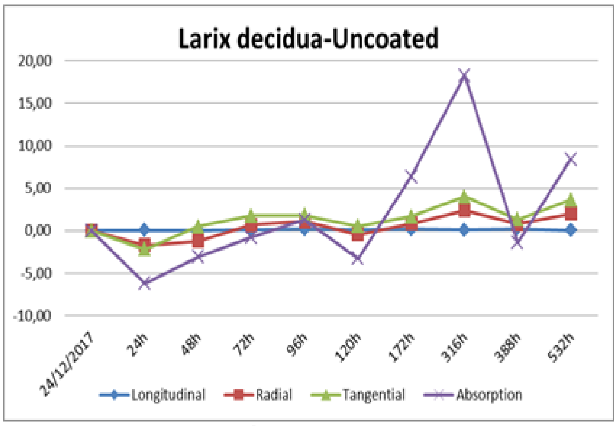

Fig. 9.
Absorption-dimension changes of Uncoated Larix decidua.

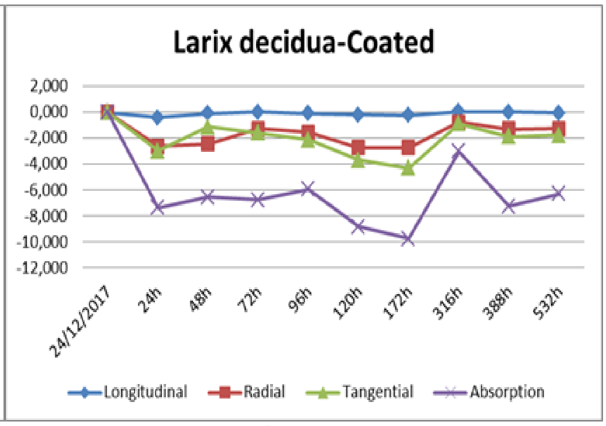

Fig. 10.
Absorption-dimension changes of Coated Larix decidua.

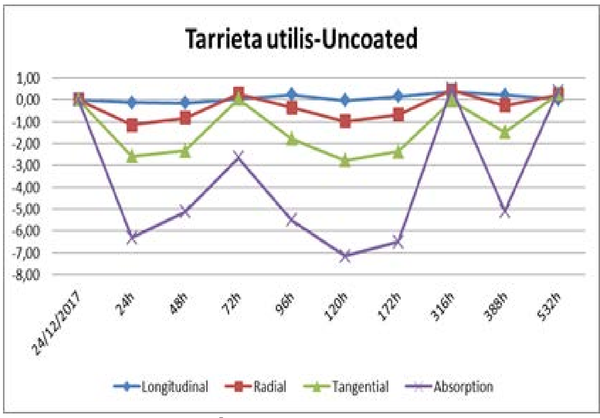

Fig. 11.
Absorption-dimension changes of Uncoated Tarrieta utilis.

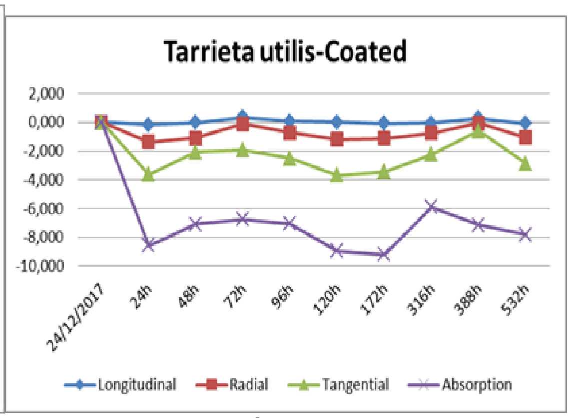

Fig. 12.
Absorption-dimension changes of Coated Tarrieta utilis.

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Tilia cordata exhibited the most intense increase of water absorption concerning the uncoated samples. However, coated samples did not show decrease as other wood species but a great increase in some cases like 96h weathering. This proves that water-soluble varnish did not protect *Tilia cordata* as it was expected.

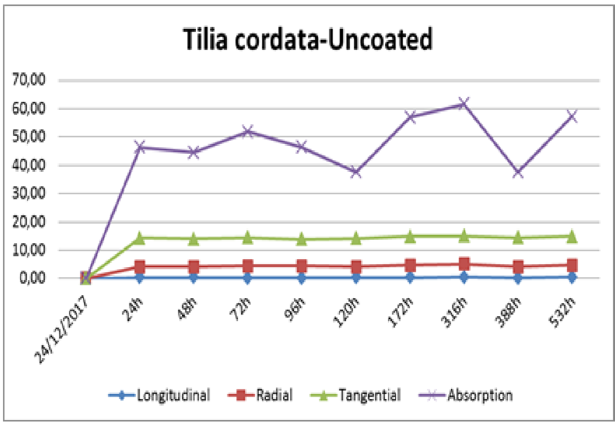

Fig. 13.
Absorption-dimension changes of Uncoated Tilia cordata.

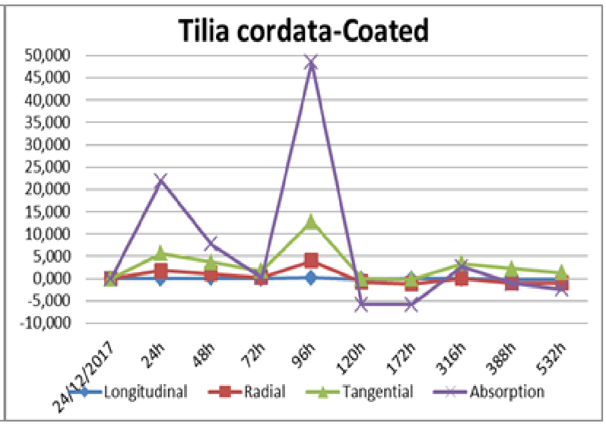

Fig. 14.
Absorption-dimension changes of Coated Tilia cordata.

Fraxinus excelsior uncoated samples did not influenced at first 24h of weathering, although as the test continuing an extensive increase was mentioned. The coated samples act in similar way as other wood species presenting reduction of water absorption and dimension change.

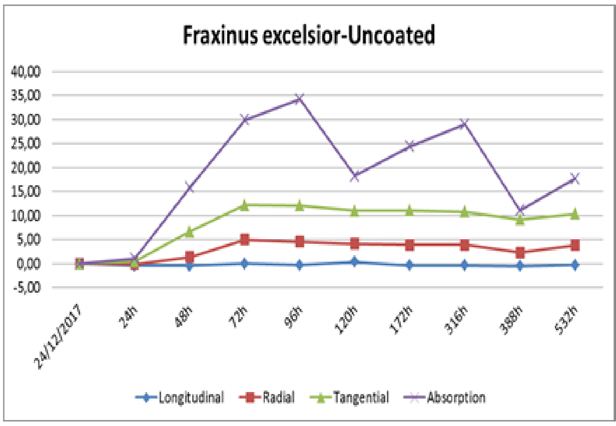

Fig. 15.
Absorption-dimension changes of Uncoated Fraxinus excelsior.

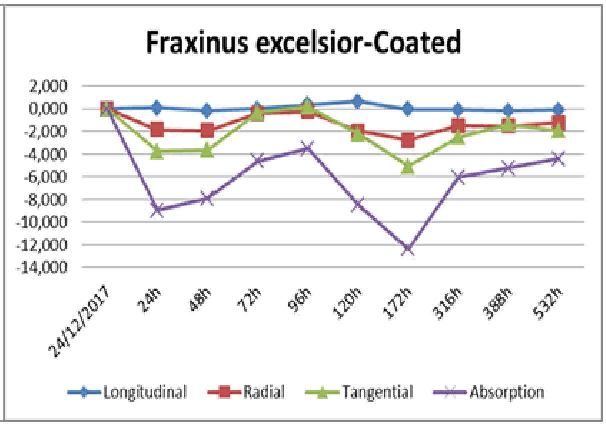

Fig. 16.
Absorption-dimension changes of Coated Fraxinus excelsior.

It is well known, that water leaks through the coated film, the wood starts swelling, causing cracks in the film and weakening the surface appearance. After a few weathering cycles, the film is extracted from the wood surface and the water without restraint diffuses in, causing dimensional changes. Subsequently, the coating is not an appropriate procedure to stabilize the wood exposed to conditions of increased humidity and action of water.

CONCLUSIONS

According to the results obtained from the coated and uncoated samples, better wood stability would be certainly achieved by coated samples. The eight wood species studied showed, however, differences in their response to artificial weathering conditions. *Tarrieta utilis* samples both uncoated and coated present reduction in water absorption and dimension changes. *Tilia cordata* exhibited the most intense increase of water absorption concerning the uncoated samples.

Longitudinal direction of all wood species shows faint changes comparing to tangential and radial directions. On the contrary, tangential direction presents highest alterations.

This research contributes to the development of a wood finishing that will improve dimensional stability of the wood weathered or exposed to UV light and water spray conditions.

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