

## Weathering Protection for Beech Wood in Kosovo

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### Abstract

*Beech wood (*Fagus sylvatica* L.) is one of the most important timber species produced in Kosovo. About 33% of the trees in our country are beech and most of the wood products are from this kind of timber. The color difference between red heart wood and white wood of the beech is significant. Adequate protection against weathering (snow, rain and low temperature) and leaching of preservative components into the environment are the main problems faced by wood companies in Kosovo as coatings defects may become apparent after only one year of outside exposure. The aim of this study was to assess the best way to protect beech wood products from weathering with available types of commercial wood coatings: film forming, non film forming, transparent stain and semi transparent penetrating stain. We concluded that the film forming and semitransparent penetrating stain are the best painting methods for beech wood products protection, according to weathering performance and coating properties.*

**Keywords:** Beech wood, coating systems, weathering, Kosovo

### 1. Introduction

During the past years, Kosovo's wood processing industry has experienced significant changes. Owing to better organization and satisfactory service-providing clusters, producers were able to increase the quality and product range, and expanded into foreign markets (IPAK 2008).

Due to the sufficient availability of trees, Kosovar wood processing companies mostly use beech (*Fagus*), oak (*Quercus*) and other broadleaves in their production. The majority of these industries produce mainly furniture, doors and other high value wood products. As a subset of the secondary manufacturing sector, there are also several enterprises engaged in cutting or milling lumber (IPAK 2008).

The anatomical structure of wood provides the superior visual and decorative properties though with a high variability between species, but also within one wood species. Especially indoors, initial color and color stability are some of the most important visual features for wood and wood-based products. Wood color can vary greatly with genetic factors (Burtin et al. 1998), and wood surface discoloration varies with environmental conditions such as solar radiation (ultraviolet, visible and infrared light), moisture (dew, rain, snow and humidity), temperature, oxygen and air pollutants (Hon and Chang 1982).

Wood discoloration is considered a superficial phenomenon due to the fact that ultraviolet and visible light cannot penetrate very deeply into the wood in order to initiate photochemical reactions, which may lead to discoloration (Hon and Ifju 1978, Hon and Shiraishi 2001; Aydın and Colakoglu 2005; Kataoka et al. 2007).

Wood color may range from almost white, as in the sapwood of many species, to almost black, as in the heartwood of black ebony (Hon and Shiraishi 2001). Irradiated wood may exhibit discoloration, cracking and roughening of the surface, damage of microstructure and loss of weight. These changes are caused by severe chemical modifications of the structure of cellulose, hemicelluloses and lignin (Hon and Feist 1992, Hon and Shiraishi 2001, Pastore et al. 2004), which could also lead to loss of mechanical properties (Turkulin and Sell 2002). Freshly felled and stored round wood discolorations are initiated predominantly through physiological reactions of living parenchyma cells for at least several weeks after felling. Typical reactions are the formation of phenolic compounds and tyloses, e.g., in beech wood and maple, triggered by oxygen penetrating the tissues (e.g. Koch et al. 2003, Koch 2004).

Discolorations can also be caused by microorganisms, for instance blue stain fungi, mould fungi, and bacteria which infect the wood surface of inadequately stored and kiln-dried wood. The described discolorations during storage can be prevented, if the changes in moisture content and temperature that favor growth of microorganisms and the initiation of physiological and

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biochemical reactions are restricted. (e.g. Koch *et al.* 2000, Koch 2004).

The present research work aims to provide information concerning surface discoloration of beech wood specie exposed outdoors, protected with different coating systems.

## 2. Materials and methods

Beech wood was selected as the most traded wood species in Kosovo. In the case of European beech (*Fagus sylvatica* L.), white heartwood as well as red heartwood were investigated, though red heart wood is not usually commercialized.

The material was exposed in five locations in different areas of Kosovo (L1 - Prishtina, L2 - Mitrovica, L3 – Peja, L4 – Prizren and L5 – Ferizaj) spanning the country in all directions.

Four coating types were tested: film forming (FF), non film forming (NFF), transparent stain (TS) and semi transparent penetrating stain (STS).

Beech wood panels generally prepared according to EN927-3 (2006) were used but with larger dimensions: 1200mm×200mm×20mm (axial × radial × tangential). Due to the high number of variables under study only a restricted number of replicates was possible, therefore all samples were represented by two test specimens.

Color measurements were performed following ISO7724-2 (1984) on the radial surface (standing annual-rings) of the planed samples. All specimens were exposed during the years 2006 and 2007 in outdoor exposure racks as described in EN927-3 (2006).

Meteorological average data for temperature, air humidity, atmospheric pressure, wind and rainfall for the years for the experiment was obtained from the National Meteorology Station of Kosovo, Prishtina, which has local stations at the five places where the experiment was conducted (table 1).

Table 1. Meteorological data for the temperature, humidity, wind speed and rainfall. Average values for the years 2006 and 2007.

Year	T-max (°C)	T-min (°C)	T-average (°C)	Relative Humidity (%)	Wind / ms <sup>-1</sup>	Rainfall (mm)
2006	16.4	5.2	11.0	73.7	1.4	580
2007	15.6	5.6	11.1	72.7	1.3	604

Color measurements were performed for each sample. Color measurements were performed prior to any exposure and intermediary color measurements were performed regularly at weekly intervals up to 4 months. Results after 30, 60, 90 and 120 days are presented here.

Changes in color of wood surfaces due to irradiation were measured using the colorimeter device Chromo Meter CR-410 (Konica Minolta, Tokyo, Japan), with a measuring diameter of 50 mm. Measurements were

performed both on the exposed, and the unexposed surface of the specimen; in that way, the same conditions were provided for exposed and unexposed surfaces from the sunshine during the measurements. Using the CIE-L\*a\*b\* color measuring system, based on D65 light source (according to CIE Commission Internationale de l'Eclairage), L\*, a\*, and b\* parameters were measured and  $\Delta E^*$  calculated. In the CIE-L\*a\*b\* system, the L\* axis represents the lightness (L\* varies from 100 for white to zero for black) and a\* and b\* are the chromaticity coordinates (+a\* is for red, -a\* for green, +b\* for yellow, -b\* for blue). L\*, a\* and b\* values are used to calculate the overall color change  $\Delta E^*$  using the following equation:

$$\Delta E^* = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$$

where  $\Delta L^*$ ,  $\Delta a^*$  and  $\Delta b^*$  are the differences between coordinates values of exposed and non exposed area of L\*, a\* and b\*, respectively. A low  $\Delta E^*$  corresponds to a low color difference. The color measurements were always performed immediately after an irradiation step in order to provide consistent conditions of the samples.

To determine the possible significance of differences among sites (Prishtina, Mitrovica, Peja, Prizren and Ferizaj), heartwoods (white and red) and types of coating (Film Forming - FF, Non-Film Forming - NFF, Transparent Stain - TS and Semi-Transparent Stain - STS), an analysis of similarities (ANOSIM) based on normalized euclidean distances using Primer version 5.2.6 statistical package (Clarke and Warwick, 1994) was performed.

## 3. Results

The analysis of similarities performed did not identify any significant difference among sites and heartwoods in terms of color changing pattern. For coatings, and with different heartwoods analyzed separately, all of them were significantly different, except NFF and TS in white beech. A trend of discoloration could be observed in all coating methods tested for both white and red heartwood, according to the overall changes in color ( $\Delta E^*$ ) after 30 days of outdoor exposure, as well as with further irradiation of up to 120 days (figure 1). After 30 days of irradiation the greatest discoloration, according to  $\Delta E^*$  values, was recorded for non film forming and transparent stain method of painting,  $\Delta E^* = 4.6$  and  $\Delta E^* = 4.9$ , respectively. After a further exposure of up to 120 days, the red heartwood of beech wood showed the  $\Delta E^*$  value of 6.1 and 4.3, respectively. Differences between 30 days and 120 days exposure for the observed beech wood specie, according to  $\Delta L^*$ ,  $\Delta a^*$  and  $\Delta b^*$  values could be observed. Different coating methods for beech wood cause different color change patterns. A further classification for white heartwood and red heartwood together with wood surface discoloration regarding their nature and intensity would render useful information.

Red heartwood surface discolored more rapidly in the first 14 days of irradiation; however the white heartwood discoloration occurred during the first 7 days.

Further exposure of up to 120 days showed a flattening behavior or a slight decrease, which leads to the conclusion that the method described was sufficiently

intensive to reach the saturation of color changes and for practical purposes, the 30 days of exposure might be sufficient for a relevant estimation of color performance. The findings of this study could give an impression of the different color behavior of the different methods of painting of beech wood specie in Kosovo exposed to outdoor area.

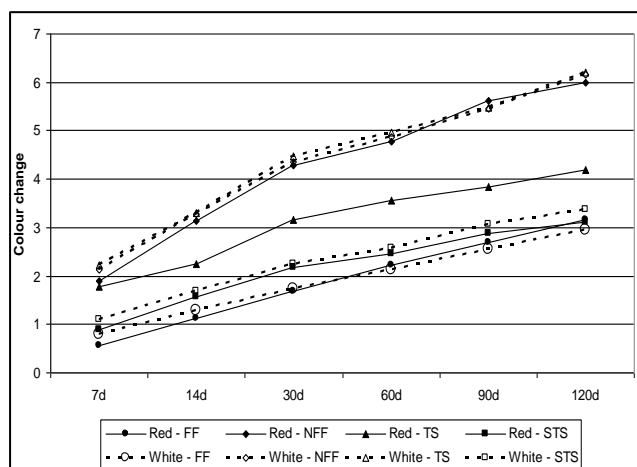


Figure 1: Results after 7, 14, 30, 60, 90 and 120 days (n=2) for film forming (FF), non film forming (NFF) coatings, transparent (TS) and semi transparent penetrating stain (STS) for red and white heartwood.

A greater amount of samples and longer exposure duration might provide more detailed information. However, in this study, an overview of the different discoloration behavior of the different methods of painting for beech wood in Kosovo concurrently could be presented. An insight on the different behavior of beech wood specie according to the CIE-L\*a\*b\* color values and how they relate to each other was given.

## Conclusions

In all stored beech wood sections considerable wood discolorations were observed as well as more or less pronounced presence of Basidiomycetes mycelia after the first year of outdoor exposure of the beech wood samples. However, discoloration must always be expected during long-term use of beech wood products. According to the available results - which need to be supplemented by investigations of further test beech wood products in Kosovo - the recommendation to industry and private owners will be the use of film forming and semitransparent penetrating stains as the more adequate painting methods for beech wood products color protection, according to weathering performance and coating properties.

In order to provide a better understanding of the phenomena involved, detailed studies on the physiological, biochemical, and chemical reactions of the extractives and cell wall components will have to be carried out on individual cases.

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