THE IMPACT OF HEARTWOOD AND SAPWOOD ON BIOLOGICAL DISCOLORATION OF A PAINTED SURFACE

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ABSTRACT

Wood material has advantages, it comes from a renewable source and it is easy to manage. But one disadvantage when used outdoors is biological discoloration of the material. Some impact on the discoloration is the presence of moisture and nutrients, necessary components for the microorganisms to grow and start a colonisation. Samples made of Norway spruce (*Picea abies* (L.) Karst) heartwood or sapwood coated with two different film forming paints was studied. The paints had a binder formula made of alkyd or acrylate. Additional parameters related to study the influence of moisture content on discoloration were high and low density material, with and without impregnation oil. Outdoor exposure was made during five years in the southern part of Sweden. The samples were hung with 45 degree inclination, facing south direction. Visual differences in biological surface discoloration were observed for samples within the same paint, which could be explained by differences in heartwood and sapwood.

Key words: Discoloration, Heartwood, Sapwood, Paint

INTRODUCTION

Discoloration of painted surfaces is one of the first sign of degradation on the material. It is also one of the most complained subjects by house owners. Fungus, bacteria and algae are common microorganisms causing discoloration on painted surfaces (Gaylarde and Gaylarde 2005). The presence of moisture and nutrients is vital for the microorganisms to establish on a surface. For untreated wood, natural material variability plays an important role for the discoloration. Sapwood has shown to have higher susceptibility to biological discoloration compared to heartwood (Blom, Johansson et al. 2013). Sapwood has also a higher water uptake compared to heartwood (Metsä-Kortelainen, Antikainen et al. 2006, Vestøl and Sivertsen 2011). Another wood parameter affecting water uptake is wood density (Sjökvist and Blom 2016).

Paint is a common alternative to protect wood surfaces. Due to the permeability of the film, interaction still occurs between the wood material and the surface. Nutrients may migrate through the film. Van den Bulcke suggested that the nutrient content in coated Scots pine sapwood is one of the reason why the surface was more severe stained

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compared to other tropical species (Van den Bulcke, Van Acker et al. 2007). Spruce sapwood coated with an acrylic latex paint has also been found to have higher degree of discoloration compared to heartwood (Sandberg 2008). One method to increase the durability of painted panels is to use impregnation oil before paint application. The oil decreases the water uptake in wood, imitating the protective function similar to extractives in heartwood.

This paper studies the impact of Norway spruce heartwood and sapwood on the biological discoloration of a painted wood surface, with emphasis on the influence from wood moisture content.

MATERIAL AND METHODS

Logs of Norway spruce (*Picea abies* (L.) Karst) from the area of Växjö, Sweden were selected and freshly cut for this experiment. At the time of felling, the sapwood border was marked. The density of the material was for low density samples 300-500 kg/m^3 and for high density samples 400-600 kg/m^3 at 12% moisture content by dry weight basis (MC). The planks where selected to be free from knots, cracks and resinous streaks. They were straight-grained and divided into heartwood, sapwood, high density and low density. The planks where dried in an industrial kiln with a maximum temperature of 70°C. The drying process was run to a MC of approximately 17%. The dried material where downsized to a sample size of 20x100x375mm (radial x tangential x longitudinal direction). All surfaces were planed to a smooth and uniform finish. Acclimatization prior to coating were made for the samples to a MC of about 12% in a climate chamber at 20°C and 65% relative humidity (RH).

The samples were coated with a water-borne alkyd (A) or a water-borne acrylate (B) paint system. The alkyd system (A) had also the combination with or without impregnation oil. All samples were coated on the side facing the bark side of the tree and on side faces and end-grains. The back sides of the samples were left uncoated. The coating was done according to the manufacturer's recommendations regarding layers, thickness and drying. The samples were dried between each layer at 20°C and 65% RH. A total of 60 samples were made with 5 replicas of each combination.

Samples were exposed outdoors during five years from October 2011-June 2016. The place where at Asa research station, 40 km north of Växjö, Sweden. The samples were hung on racks vertically on a 45-degree inclination to the south. Every second month, the samples were weighed with an accuracy of 0.1g. The MC by dry weight basis for the samples was calculated from the weight. Mould growth were measured in June 2016 according to standard EN ISO 4628-1 (Standardization 2004) using grade 0-5 (Fig. 1), where grade 0 = no detectable defects / discoloration up to grade 5 = dense pattern of defects/discoloration.

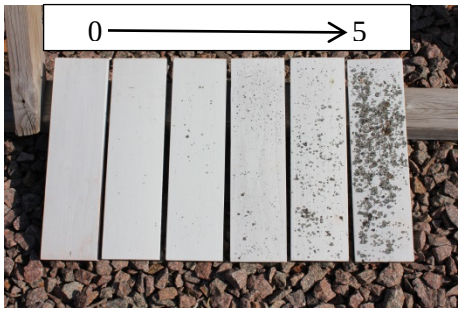

Fig. 1: Grades of defects / discoloration according to standard ISO 4628-1:2004. Left panel grade = 0, Right panel grade = 5.

RESULTS

The discoloration of sapwood samples was higher or at equal level compared to heartwood for almost all samples, Fig. 2. The only combination with lower discoloration on sapwood than heartwood was for low density spruce coated with an acrylate system (B).

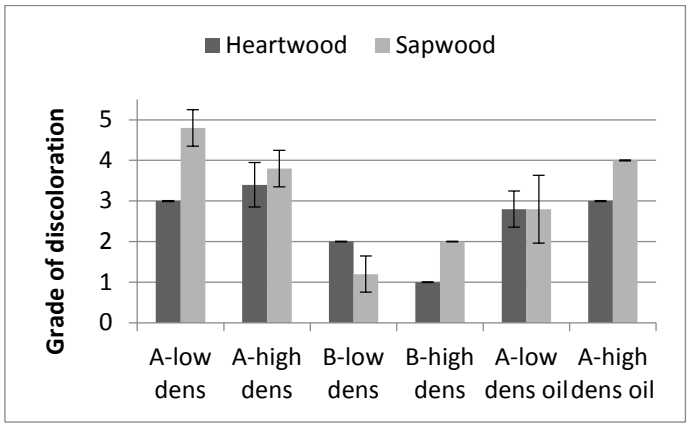

Fig. 2: Grade of discoloration with standard deviation illustrated as error bars. Sample combinations: A=alkyd, B=acrylate, high density spruce, low density spruce and oil impregnation.

Largest difference in discoloration between heartwood and sapwood was found in samples painted with alkyd system (A) without impregnation oil as illustrated in Fig. 3.

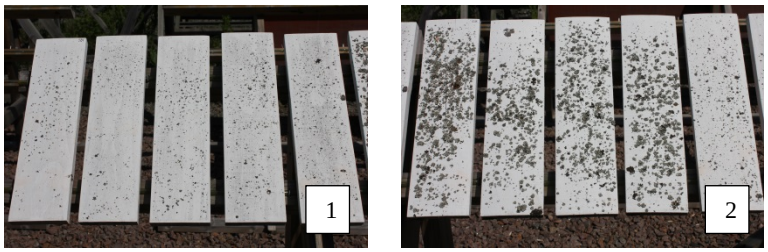

Fig. 3: Discoloration of Spruce panels coated with an alkyd system (A), low density and no impregnation oil, picture 1=heartwood, picture 2=sapwood.

All samples treated with impregnation oil except one combination had similar or slightly less discoloration compared to corresponding samples without impregnation oil

(Fig. 2). The only exception was for high density sapwood. No correlations could be found between density of spruce and degree of discoloration.

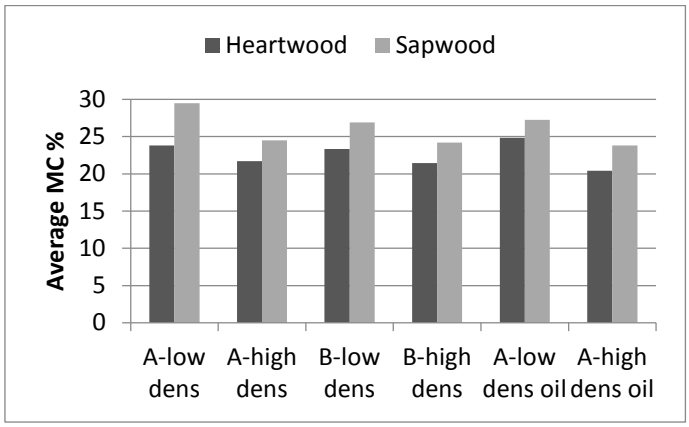

Fig. 4: Average moisture content. Sample combinations: A=alkyd, B=acrylate, high density spruce, low density spruce and oil impregnation.

The average MC was calculated as the average of all collected data for each sample combination independent of the time of data collection. The result is illustrated in Fig. 4. Sapwood samples had higher MC compared to heartwood samples for all combinations. Low density spruce samples had higher MC compared to samples with high density spruce for all sample combinations. The oiled samples had lower MC compared to corresponding samples without impregnation oil for all combinations except for low density heartwood.

DISCUSSION

The result with higher discoloration for sapwood is similar to previous result with uncoated spruce (Blom, Johansson et al. 2013) and also for coated spruce (Sandberg 2008). The trend was clear for samples painted with an alkyd system (A) but had some ambiguity for the acrylate system (B). The exception from the trend was sapwood samples made of low density spruce and coated with an acrylate system (B). This is in contradiction with previous results by (Sandberg 2008) who tested a similar paint system made of acrylic latex. It can be difficult to compare between different paint systems. The only known ingredient in the paints is the binder. For example is the amount of biocides unknown. The amount of biocides has an impact on the degree of discoloration. Effectiveness to reduce the discoloration by the biocide depends on the amount and the type of chemical, which there are limited information about. Conclusions can therefore only be made on the differences within the same paint system.

Samples with impregnation oil had in general lower discoloration compared to its corresponding samples without impregnation oil, Fig. 2. Exception was found for high density sapwood samples with higher discoloration on the oiled samples. The difference in discoloration for the deviated data is too small (without oil = 3.8, with oil = 4.0) and within the standard deviation interval for being considered as relevant.

When studied the differences of MC in Fig. 4, one could see that sapwood gained higher average MC compared to heartwood, in all combinations. The higher water uptake for coated sapwood samples is similar to the behaviour shown for uncoated samples (Metsä-Kortelainen, Antikainen et al. 2006, Sivertsen and Flæte 2012). The result with higher MC for low density samples compared to high density samples was also similar to previous experiments shown by Sjökvist (Sjökvist and Blom 2016).

It seems to be a correlation when comparing degree of discoloration in Fig. 2 and average MC in Fig. 4. Samples made of sapwood have both higher discoloration and higher MC compared to samples made of heartwood. Moving to the samples with impregnation of oil, these samples had lower MC compared to correlated samples without impregnation of oil. The oil treated samples had as well lower degree of discoloration compared to samples without impregnation oil. Low density samples had higher MC but no correlations could be found with a higher discoloration. In contrary, it seems to be randomized.

CONCLUSIONS

New findings raised new questions. Samples made of sapwood with an alkyd based paint had higher discoloration compared to heartwood. The MC was also higher for sapwood that heartwood samples. Low density wood had higher MC than high density wood but it didn’t correlate to a higher degree of discoloration. The question remained to be answered in future work is; whether the difference in discoloration is because of the presence of nutrients in sapwood or the higher MC in sapwood.

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