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Less Yellowing by Sealing the Knots

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Abstract

The discoloration of paints applied on wood knots or on tropical woods has always been a problem. Extractive components from the wood brought to the paint surface by water vapour or mono- and di-terpenes are affected by the UV-light and undergo chemical modification by photo-oxidation. The result is coloured products discolouring the paint. A water borne polymer dispersion which binds the extractive compounds has been developed. Used as a clear sealer or pigmented primer the polymer dispersion prevents the extractives from the wood or the knots to penetrate the film of the top paint. But the water vapour and terpenes can still evaporate through the primer film.

Introduction

Wood is a complex polymeric structure consisting of lignin and carbohydrates such as cellulose and hemicelluloses, which form the visible lignocellulosic structure of wood. The morphological and chemical character of knots is different from normal stem wood. Usually knots contain large amounts of extractives [1]. For example Norway spruce knots contain exceptionally large amounts of lignans, 6 – 24 weight percent, which is 30 – 500 times the amount found in stem wood. On the other hand knots of Scottish pine contain large amounts of phenolic stilbenes, 1 – 7 weight percent, while the stem wood contains only around one weight percent stilbenes [2].

After the wood and the knots have been painted water vapour and mono- and diterpenes are evaporated through the paint film. When evaporating the water and the terpenes bring extractives like lignans and phenolic stilbenes to the paint film. Under UV-light exposure the extractives undergo chemical modifications by photo-oxidation [3] leading to the production of coloured compounds [4] discolouring the paint.

In attempts to chemically immobilise the extractives several approaches have been followed. The common methods to prevent extractives from bleeding through the coating are either creating a dense barrier or including species in the primer that can interact with the extractives. Examples of systems which have been used are urethane modified alkyds [5], two-component binder systems containing tertiary amine functional acrylic dispersion in combination with an epoxy functional acrylic binder [6], anionic polymer dispersions in combination with reactive pigments like zinc oxide [7] and cationic waterborne dispersions [8]. However formulating cationic dispersions requires the use of cationic dispersants and restricts the choice of pigments and other paint additives.

In an earlier study [9] it was found that a vinyl acetate based polymer dispersion containing functional groups binding the extractives from the knots can successfully be used as an extractive locking and a knot sealing primer. In this study the performance of this type of stain locking binder has been further improved.

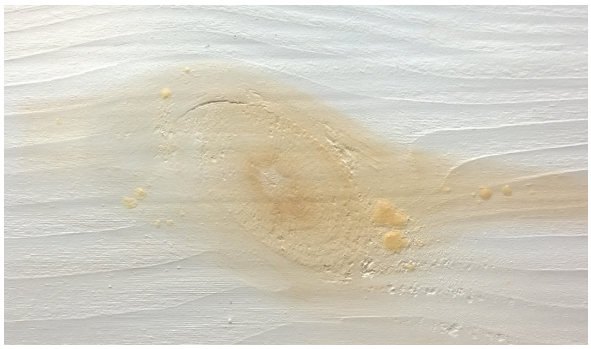

Figure 1. Extractives in the knot discolour the top coat.

Materials and Methods

To investigate the barrier properties of different water borne binders we initially applied them as such on knot containing wood panels of Finnish pine. Furthermore, the barrier properties were tested on the tropical wood merbau.

The binders or primers were applied by brush once or twice with a drying time of at least half an hour between the applications. As the top coat a white acrylic water borne trim paint was applied. The panels were dried for 24 hours at room temperature and then put into a QUV accelerated weathering tester for 24 hours. The tester was run in cycles of four hours UV-light and four hours moisture treatment.

The discoloration of the knots was determined by measuring the colour of the knots before and after the test and ∆E values describing the change of colour according to the CIE L*a*b*-system were calculated. The ∆E values reported are numeric average values of at least three different panels. On the merbau panels the primer was also applied once or twice and the same trim paint as above was applied as a top coat. The discoloration appeared immediately or within 24 hours at room temperature and did not significantly change after that.

Pigmented Stain Locking Primer	**P 342-1**
Pigment Grind:	
Water	35,0
HEC Thickener, medium molecular weight	0,8
Byk 022	0,2
Polycarboxylic Acid Dispersing Agent, solids 44%	0,5
Titanium Dioxide	30,4
Calcium Carbonate, 2 µm	40,0
Talc, 4,5 µm	20,0
In-can Preservative	0,2
Let Down:	
Stain Locking Binder, solids 46 %	284,0
Defoamer	0,6
Total	**411,7**
Solids	53,9
PVC	20,0
Dispersion / Total Paint	69,0
Primer Properties	
pH	8
MFFT	7

Table I. Formulation of the tested pigmented stain locking primer.

A pigmented stain locking primer was made according to the formulation in Table I and tested in the same way as described above.

Results and Discussion

Two commercial acrylate dispersions marketed for stain blocking applications, a versatile styrene acrylic and a versatile vinyl acetate dispersion together with the novel stain locking binder were applied in two layers on knotty pine panels and coated with the white trim paint. After testing in the QUV tester the result was strong discolouration of the top coat at the knots with ∆E values equal to or higher than 5, Figure 2. The only exception were the knots coated with the novel stain locking binder, which didn't give any visible discolouration but a measured ∆E value of about 1. This means that two layers of the stain locking binder effectively locks the extractives from the knots.

To further investigate the efficiency of the novel stain locking binder big pine knots were divided into three parts, Figure 3. The middle part was coated twice with the stain locking binder, the lower part was coated once and the upper part was not sealed. The whole panel was painted with the white trim paint and tested in the QUV tester. With two layers of stain locking binder no discolouration was seen and $\Delta E < 1$. One layer of stain locking binder gives a slight discolouration of the top coat with $\Delta E \approx 2$. The slight discolouration is caused by the extractives not completely bound in the stain locking layer thus slightly discolouring the top coat. Two layers of the stain locking binder bind all the extractives and therefore no discolouration of the top coat can be detected. The upper part with no stain locking binder is heavely disoloured.

The same test was done with the pigmented stain locking primer, Figure 4, and the same trend could be seen. Two layers of primer give an excellent extractive barrier with $\Delta E < 1$. One layer gives a slight discoloration with $\Delta E < 3$ and no stain locking binder a heavy discoloration with $\Delta E > 10$.

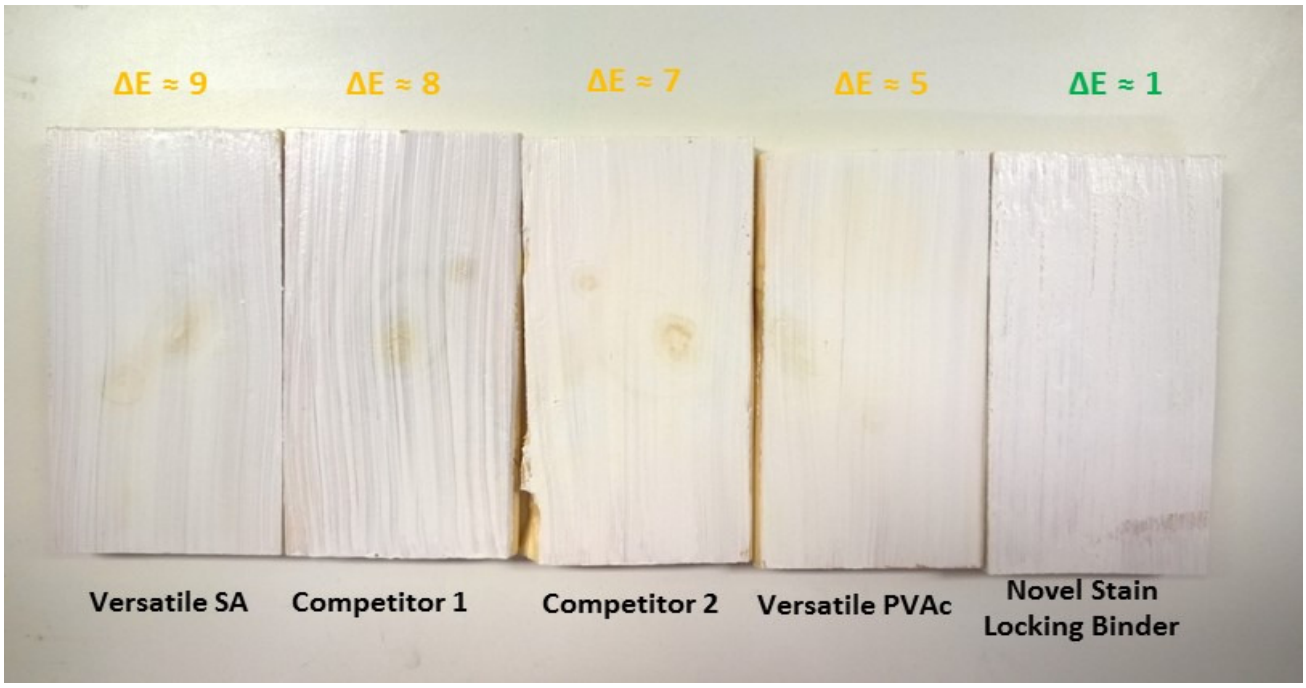

Figure 2. A commercial styrene acrylic binder, a poly vinyl acetate binder and two acrylate binders sold as stain locking binders (competitors 1 and 2) were tested on knotty pine panels together with the novel stain locking binder. The discolouration of the top coat at the knots was measured.

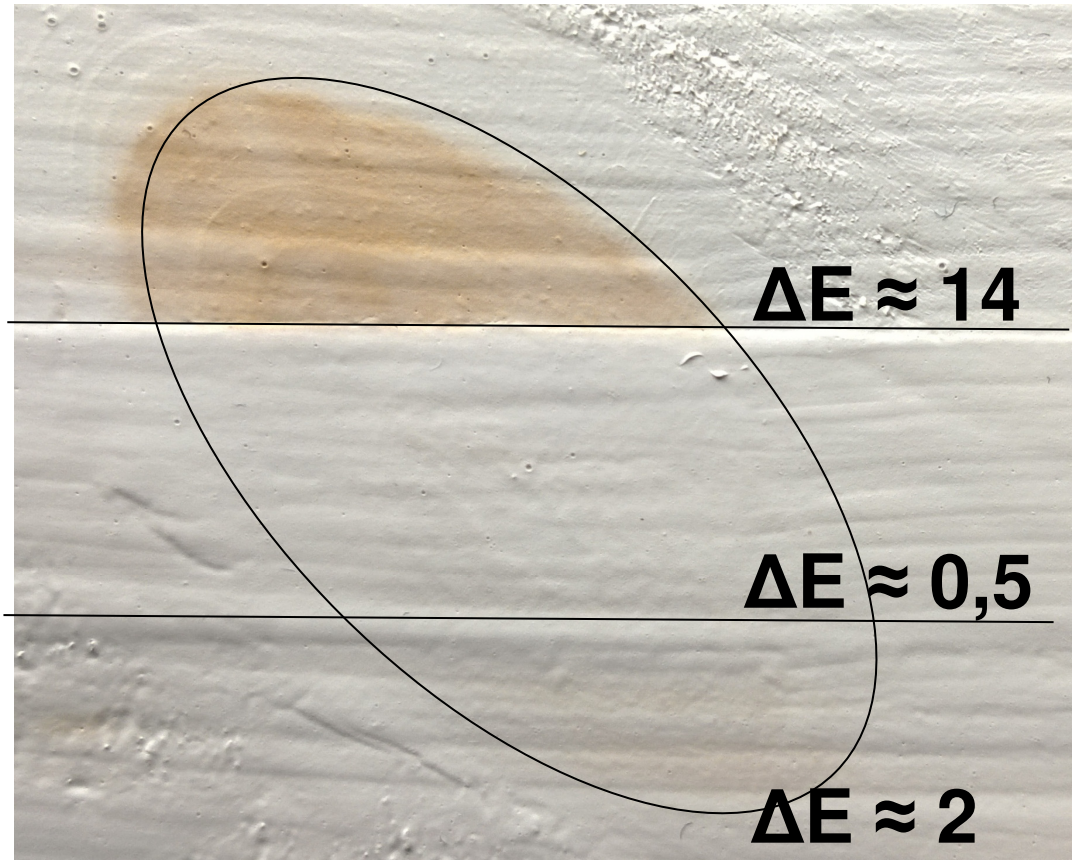

Figure 3. A pine knot with no stain locking binder (top) gives heavy discoloration, two layers of stain locking binder (in the middle) gives no discoloration and one layer of stain locking binder (bottom) gives a slight color change of the top coat.

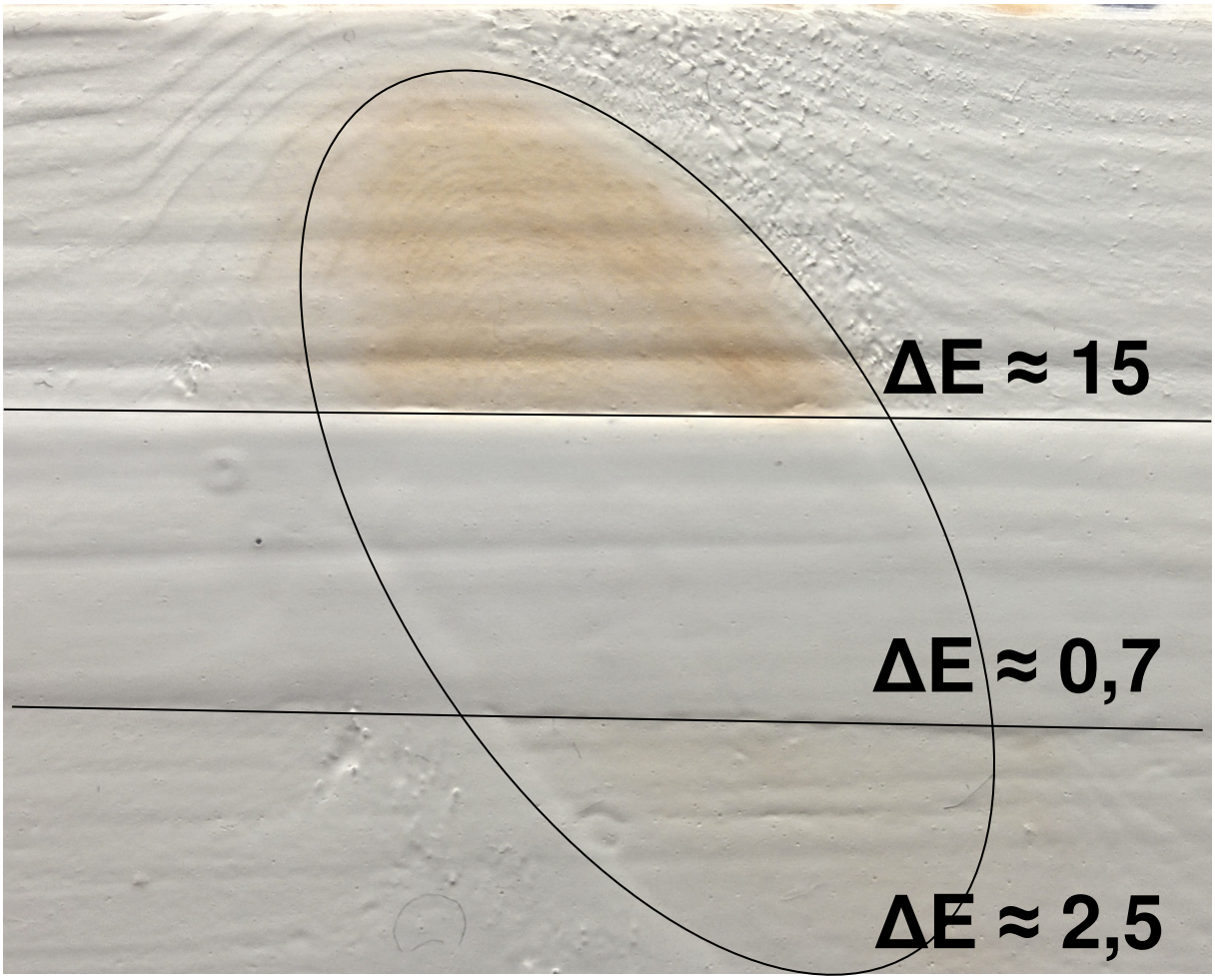

Figure 4. A pine knot coated with no stain locking pigmented primer (top) gives heavy discoloration, two layers of pigmented primer (in the middle) show no discoloration and one layer of pigmented primer (lower part) gives a slight discoloration of the top coat.

Figure 5. Stain locking binder as such (top) and the pigmented stain locking primer (bottom) applied one layer to the left and two layers to the right on merbau and coated with the trim paint.

Both the stain locking binder and the pigmented primer were tested on merbau, which contains a lot of extractives and is hence very demanding, Figure 5. One layer of stain locking binder or primer does not bind all the extractives from the wood. Application of two layers give an excellent barrier and no discoloration of the top coat.

To investigate the amount of binder needed the pigmented stain locking primer was further made by different amounts of stain locking binder down to 40 % wet binder of the formulation. With 60 % and 50 % binder the extractive locking properties were still good but with 40 % binder a loss in the properties were seen. This means that to get good stain locking properties at least 50 % of wet binder is recommended in the pigmented formulation.

Conclusions

A vinyl acetate based polymer dispersion containing functional groups binding to the extractives from the knots can successfully be used as a extractive locking and knot sealing primer. As such the binder can be used as a clear knot lacquer and gives excellent stain locking properties. In a pigmented primer the amount of stain locking binder is recommended to be at least 50 weight percent to maintain the good barrier properties. One layer of primer gives a good barrier and two layers give outstanding stain sealing properties.

Sealing properties of other types of components will be investigated in a separate study.

Acknowledgements

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