Novel Coil-coating Concept for Modified Wood

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ABSTRACT

A new approach to coat thermally modified wood has been studied. A modified version of a partially bio-based paint formulation for pre-coating of sheet metal, *i.e.* coil-coating, developed within EcoBuild competence centre has been used for thermally modified wood panels. The coating system basically consists of a polyester binder, a melamine cross-linker, and a fatty acid methyl ester (FAME) as reactive diluent. In the present work, a rape seed methyl ester (RME), *i.e.* "bio-diesel", has been used as reactive diluent. Cure is performed at high temperature with a short dwell-time during what RME undergoes trans-esterification with the polyester. The formed coating is tough, hard, and flexible with an expected service life of 15-20 years. This type of coating system would be impossible to use for unmodified wood substrates due to moisture induced foaming during the high temperature curing step. However, for thermally modified wood, this type of system could theoretically be used and result in very durable coating films. Thermally modified spruce (ThermoWood D) panels have been coated with the novel coil-coating resin and cured at approximately 180 °C. Liquid water permeability, adhesion, and other complementary conventional film characterization tests have been performed on the coated wood panels. The test results show that this type of coating performs well on thermally modified wood.

INTRODUCTION

The EcoBuild project "reactive diluents in coil-coatings" has explored the concept of incorporation of reactive diluents derived from vegetable oils into thermally cured polyester/melamine coil-coating systems. Conventional thermally cured solvent-borne coil-coating paint is applied to metal substrates and cured in high temperature convection ovens for ~37 seconds at 300 ºC to reach a peak metal temperature of approximately 230 ºC. A reactive diluent is a compound that acts as a solvent in the liquid paint, lowering the viscosity, and further chemically reacts into the final film during cure. Therefore, the benefits from using vegetable oil derivatives as reactive diluents are two-fold; the amount of volatile solvents is reduced and the final film will partly consist of a renewable feedstock. The project showed that a fatty acid methyl ester (FAME) reactive diluent can be incorporated into a hydroxy-functional polyester/melamine coating through transesterification without deteriorating the final film properties. (Johansson *et al*. 2005, Johansson *et al*. 2006, Johansson 2008, Johansson *et al*. 2009). In the present work, the concept of coating modified wood with a coil-coating formulation containing FAME as reactive diluent has been explored. Three types of modified wood; thermally modified spruce, acetylated pine, and furfurylated southern yellow pine, have been evaluated as they are less heat sensitive than non-modified wood. Adhesion, scratch resistance, and water permeability of the coil-coating films on wood substrates have been studied. Test panels for natural weathering testing have also been prepared.

EXPERIMENTAL

Materials

Three types of modified wood have been evaluated; thermally modified spruce of class Thermo-D (D=durable) (ThermoWood), acetylated pine and furfurylated southern yellow pine (SYP). ThermoWood D was supplied by SP Trätek. The acetylated pine was obtained from Pia Larsson Brelid, SP Trätek. The furfurylated SYP was supplied by Kebony ASA. Three coil-coating formulations, *i.e.* two pigmented formulations (**V1** and **S2**) and a clear-coat (**K3**) supplied by Akzo Nobel Nippon Paint AB were used. Data for **V1**, **S2** and **K3** are given in Table 1.

Table 1: Data for W1, B2 and C3

Sample	V1	S2	K3
Colour	White	Black	Clear-coat
Pigment volume [wt%]	35	2	-
Dry weight [wt%]	85	73	79
Viscosity [Pa s]	1.8	2.5	2.5

Procedures and characterization

Films were applied on planed wood substrates with pull-down bars to yield a wet film thickness of 12, 24, 40, 60, 80, or 100 µm. The films were thermally cured in a convection oven (Memmert, Schwabach, Germany) at 140 °C and 180 °C respectively for 10, 15, 20, or 30 min. Adhesion and scratch resistance was determined by scratching using the nail and by crosshatch tests according to ISO 2409. Chemical resistance was evaluated according to EN 13523-11 Liquid water permeability was tested according to SS-EN 927-3:2007. Panels coated with **V1** and **K3** were prepared according to SS-EN 927-3:2007 for natural weathering testing.

RESULTS AND DISCUSSION

Film formation and cure

Coil-coating paint is known to boil during cure if it is applied too thick and in the case of substrates containing volatile compounds. This makes it important to use planed wood substrates and an adequate film thickness. Visual inspection of samples of different film thicknesses shows that boiling occurs when the evaluated paints are applied with a film thickness greater than 24 µm. Further, visual inspection of the samples disclosed that different regions on the wood panels have different ability to absorb paint, rendering uneven film thicknesses and film defects, *e.g.* blistering. The ability to absorb paint during cure also differs between the three different substrates. The acetylated pine show the greatest absorption causing problems with pigmented formulations as the binder is absorbed and the pigment is left on the surface. This problem was solved by priming the acetylated wood with the clear-coat and thereafter applying the pigmented coating. In the present study cure has been performed at 140 °C and 180 °C respectively and the degree of cure has been determined by MEK rubbing.

The results show that a shorter cure time is required to obtain cured film at the higher cure temperature. The clear-coat cures faster on acetylated wood than on ThermoWood due to the more acidic surface of the acetylated wood. However, this is not the case for the pigmented coatings due to the previously mentioned greater absorption properties of the acetylated wood. Coatings on furfurylated wood substrates cure at a shorter cure time at 140 °C, but require a somewhat longer cure time at 180 °C compared to coatings on ThermoWood substrates.

Film characterization

Adhesion, scratch resistance and film thickness of ThermoWood panels coated with one and two layers of **S2** were determined. The evaluated coatings have good adhesion to ThermoWood. However, the cross-hatch adhesion test yielded a value of 2 as pieces of the wood was pulled of together with the coating due to the poor mechanical properties of ThermoWood (Finnish Thermowood Association 2003), *i.e.* the coatings have good adhesion to ThermoWood. Furthermore, the poor mechanical properties of ThermoWood entail poor scratch resistance of the studied coatings as the substrate is easily scratched.

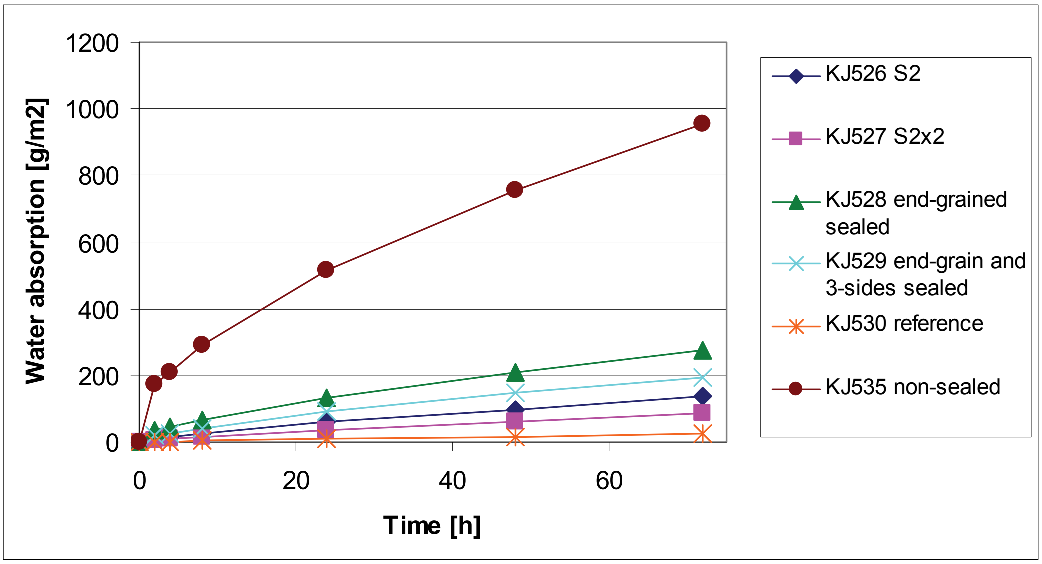

Figure 1: Water absorption versus time during water uptake.

Water permeability

The water permeability for one and two layers of **S2** on ThermoWood panels and neat ThermoWood panels with different degree of sealing has been tested. The water absorption versus time for the water uptake is shown above (Figure 1). The reference sample's, KJ530, water absorption does not exceed 30 g/m^2 indicating that the test is valid. The water absorption is decreased with approximately 30% by applying a layer of **S2** and with another 30% with a second **S2** layer.

Natural weathering

Coated ThermoWood and acetylated wood panels, samples **A** and **B**, were prepared for outdoor natural weathering exposure testing. Preliminary results from these ongoing tests will be discussed at the ECWM conference.

CONCLUSIONS

Thermally modified, acetylated and furfurylated wood panels have successfully been coated with coil-coating paint. It has shown to be of importance to have planed substrates to avoid film defects, *e.g*. blistering. The coatings exhibit good adhesion to all three substrates. The scratch resistance for the coatings on thermally modified wood is poor as the mechanical properties of the substrate are poor. The acetylated pine absorbs the paint greatly and needs to be primed several times with the clear-coat to avoid chalking of pigmented coatings. Coating of wood panels with coil-coating paint decreases the ability to absorb water.

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REFERENCES

Johansson, M., Svensson, M., Sundell, P.-E. (2005). New method for production of thermally cured coatings. *WO2005/052070*

Johansson, K., Johansson, M. (2006). A Model Study on Fatty Acid Methyl Esters as Reactive Diluents in Thermally Cured Coil Coating Systems. *Progress in Organic Coatings* **55**, 382-387.

Johansson, K., Bergman, T., Johansson, M. (2009). Hyperbranched Aliphatic Polyesters and Reactive Diluents in Thermally Cured Coil Coatings. *ACS Applied Materials & Interfaces* **1,** 211-217

Johansson, K. (2008). Thermally Cured Coil-Coatings Utilizing Novel Resins and Fatty Acid Methyl Esters as Reactive Diluents. *PhD-thesis, Royal Institute of Technology, Stockholm, Sweden*

Finnish Thermowood Association, ThermoWood Handbook, Helsinki, Finland (2003), www.thermowood.fi