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WOOD COATINGS

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INTRODUCTION

Wood is a renewable material and has many diverse uses. Unfortunately, wood is susceptible to various degradation processes. Therefore, wood preservation is required to protect wood. Coating is one of wood preservation technologies widely used for protection and decorative purposes. The proper coating method avoids esthetical changes such as color degradation or occasional growth of decay fungi and bacteria thus extending the service life of wood (Herrera 2015). Besides, coating can also protect wood against water, weathering and humidity (Viitanen 2010). The surface properties of wood can be raised easily by finishing with coatings to provide different performance characteristics for individual applications such as: high hardness, better impact resistance, suitable gloss, and better chemical resistance. Furthermore, functional coatings such as fire retardant coatings can increase the added value of wood products (Chang 2012). Meanwhile, the used of TiO_2 and ZnO nanoparticles in coatings as UV blocking agents can improve the UV protection properties of wood (Mirela et al. 2011). This paper describes the fundamentals of coating systems and addresses the influence of coating to protect wood from degradation agents. Techniques to measure the quality of coating system in protecting wood are also discussed.

COATING SYSTEMS

The terms 'coating' refers to a generic name for all types of paints, varnishes, lacquers, etc (Meijer 2001). Coatings usually exist in form of a dispersion of binders, solvents, pigments, and additives (Lambourne 1999). It may be defined by their appearance (e.g., clear, pigmented, metallic, or glossy) and by their function (e.g., corrosion protective, abrasion protective, skid resistant, decorative, or photosensitive). Other than that, it also can be characterized as organic and inorganic coating. For instance, many coatings consist of inorganic pigment particles dispersed in an organic matrix (the binder) (Wicks 2007). The composition of coatings and its function are indicated in Table 1.

Table 1 The composition of coatings

Composition	Typical function
Binders	Materials that form the continuous film that adhere to the substrate (the surface being coated), and bind together the other substances in the coating to form a film
Solvent	The means by which the paint may be applied
Pigments	Provide colours and opacity to the coating film
Additives	Materials that are included in small quantities to modify some properties of a coating

Source: Banov (1982)

CLASSIFICATIONS OF COATINGS

Generally, coatings are classified into three groups by how they cure: evaporative, reactive and coalescing. Evaporative coatings are cured from the bottom up, thus the top is the last part to cure. Besides, reactive coatings undergo polymerisation, and the resultant material is less readily dissolved in solvents. Lastly, coalescing coatings, basically water-based, are more complex than the other 2 types (Flexner 2010). The classification and type of coatings are shown in Table 2.

Table 2 The classification of coatings

Classification of coatings	Type of coatings
Evaporative coating	Wax, lacquers, shellac
Reactive coating	Varnishes, polyurethane
Coalescing coating	Water-based

Source: Flexner (2010)

SELECTION OF THE COATING SYSTEM

An important factor in selecting a suitable coating system is the capability of the coating to impede any wood degradation agent from degrading wood. The coatings selected depends upon two major factors which are the type of surface to be coated or treated and the function of product (Soderberg 1969). End uses for exterior wood are categorised according to the degree of dimensional stability required. 'Stable' refers to joinery, windows and doors; 'semi-stable' refers to many types of cladding and 'non-stable' refers to most types of fencing. The main bulk of decorative coating for interiors is for walls and ceilings, which are predominantly, plaster-based substrates (Bulian 2009). The type of coating produce would depend on the end usage of wood products either for indoor or outdoor application, thus choosing the right coating is very important (Anwar 2016). The following Table 3 shows the various materials available for wood coating.

Table 3 Materials for wood coating

Materials of coating	Function
True oils	**Linseed oil** - Rarely used on wood because it dries so slowly. For wood finishing, the only linseed oil that can be used is boiled linseed oil. **Tung oil** - The heat-treating process makes the oil a bit more durable and speeds up the drying time
Varnishes	- Made of tough and durable synthetic resins that have been modified with drying oils. - The list of resins includes alkyd (standard for all purpose interior variety with decent protective qualities), phenolic (usually made with tung oil, is predominantly for exterior use), urethane (also called polyurethane, offers a better resistance to heat, solvents and abrasions than any other varnish) and the oils (tung oil and linseed oil) - Cures by the same process as true oils which is polymerization but the resins make this finish more durable than oil.
Oil and varnish blends	- Will dry a bit harder than true oils, and the finishes will build quicker with fewer applications. Oil-based varnish is the most durable finish that can be easily applied by the average woodworker
Shellacs	- Available in several varieties either premixed, flake form or mixed with denatured alcohol
Lacquers	**Nitrocellulose -** made from an alkyd and nitrocellulose resin, dissolved and then mixed with solvents that evaporate quickly **Acrylic -** modified lacquer that is made from a mixture of a nonyellowing cellulose resin (called cellulose acetate butyrate (or CAB) and acrylic.

Source: Jeff (2000)

FACTORS INFLUENCING THE QUALITY OF COATED WOOD

Application of coating materials onto the wood surface leads to the creation of an interface between the coating material and the wood. The chemical constitution of the wood substance as well as the morphology of the wood surface affects the process of wetting and adhesion at the interface between the coating (in the liquid phase) and the wood material (Liptakova 1995). There are several factors that influence the quality of coated wood, and they are:

1) geometry of the substrate surface
2) viscosity of coating materials
3) wood moisture content
4) various stress states in the system, etc.

All of these factors must be considered when studying wood coating systems because they may cause a considerable distortion of interactions among the surface forces, and influence the conditions at the interface between the wood and the liquid coating material. They can also have a negative impact on the stability of the final wood coating system (Kudela 2012). However, the wood surface can be improved through sanding process. There are various types of sandpaper and grit. Usually sandpaper used in woodworking is produced from flint, emery, garnet, zirconia alumina, aluminium oxide and silicon carbide. There is a range of grit sizes that are effective for the wood working. The higher number of grit, the finer the grade (Bulian 2009). Table 4 shows the sandpaper grit for woodworking.

Table 4 Sandpaper classification

Sandpaper grit	Common definition
#40, #60, #80	Very coarse
#100, #120, #150	Coarse
#180, #200, #240	Medium
#280, #320, #360	Fine
#400, #500, #600	Very fine
#700, #800, #900	Ultra-fine

Source: Bulian (2009)

APPLICATION OF WOOD COATING

Once the wood surface is prepared, the wood coating will be applied. There are several methods that can be used to coat the wood surface such as brushing, dipping, spraying etc. The selection of coating method depends on the wood products and the environmental conditions in which wood will be used. Figure 1 and 2 show the examples of finishing method for wood coating application.

Table 5 Type of methods, advantages and disadvantages for each of the coating techniques

Methods	Type of products	Advantages	Disadvantages
Brushing	Architectural painting (building)	Low cost, high-transfer efficiency, low capital cost	Low productivity, relatively low quality of the final result
Curtaining	Flat surface	Fast, capable systems operating up to 100 m^2/min,	Complex cleaning and maintenance
Dipping	Elements presenting complex shapes with difficult accessible sides	Economic, fast application system, low viscosity	Coating thickness control, solvent refluxing
Flowing	Three-dimensional elements (example: window frames or chairs)	High productivity	Coating thickness control, solvent refluxing
Spraying	Powder coatings / solvent coating	Most efficient in paint usage, minimum overspray	Higher cost of equipment, slower operation
Rollering	Stains (solvent or water-based) and one-component coatings (primers, priming coats and topcoats)	Good productivity, capability to use high solid content coatings	Not suitable for the application of two-pack systems which have a limited pot life

Source: Collier (1967)

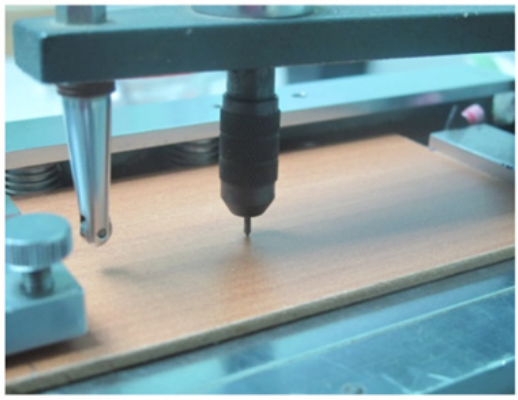
Figure 1 Spraying technique

Figure 2 Brushing technique

PERFORMANCE OF COATED WOOD

The performance of coatings can be evaluated using several tests based on local and international standards. The coated wood should be tested to know the service performance of wood after coating (Ekstedt 2002). Some tests (Figure 3) for coated wood products include such as impact resistance, adhesion (pull off test/cross cut), abrasion, scratch, dry heat, temperature-change, household chemicals and other. There are a few tests available at the Wood Finishing Laboratory, FRIM, such as shown in Table 6.

(a)



(b)

(c)

(d)

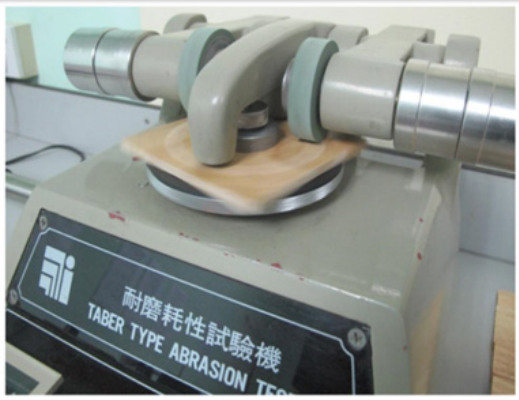


Figure 3 Type of tests conducted in Wood Finishing Laboratory: (a) Scratch (b) Pull-off test (c) Cross-cut test (d) Abrasion test

Table 6 Type of testing

Type of test	Objective
Abrasion	To evaluate the performance of wood finishing against wearing due to friction
Impact resistance	To determine the resistance of wood finishes against impact
Adhesion	1) Cross-cut: To determine the adhesion properties between wood and coating. 2) Pull-off : To measure the bond strength between the coating and wood substrate
Scratch	To measure the performance of finishing material against scratching
Dry heat	To assess the resistance of a wood finishing system to marking by using a standard aluminium alloy block placed on the wood at a specified test temperature.
Temperature-change	To determine the resistance to checking and cracking of the clear nitrocellulose lacquer films applied to wood or plywood substrates when subjected to sudden changes from high to low temperature
Household chemicals	To evaluate the effect of household chemicals on clear and pigmented organic finishes, resulting in discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or any other defect.

Source: Anwar et al (2016)

CONCLUSIONS

The protection of wood is largely based on the properties of coatings and the wood properties. The selection of correct coating systems, technique and understanding the properties of wood (chemical constituents, moisture content, morphology of wood surface structure) are important in producing high quality coated wood products.

REFERENCES

Anwar UMK, Siti Rafidah M, Hamdan H & How SS. 2016. Value adding wood products by wood finishing. *Timber Technology Bulletin*, 66, Forest Research Institute Malaysia (FRIM).

Banov A. 1982. *Paints & Coatings Handbook*. Second Edition for Contractors, Architects Builders and Engineer, McGraw-Hill Book Company.

Bulian F & Graystone J. A. 2009. *Wood coatings. Theory and Practice*, Elsevier B.V.

Chang CW & Lu KT. 2012. Natural castor oil based-package waterborne polyurethane wood coatings. *Progress In Organic Coatings*, 75, 435-443, Elsevier.

Collier J. 1967. *Wood finishing*. Pergamon Press.

Ekstedt J. 2002. Studies on the Barrier Properties of Exterior Wood Coatings, Doctoral Thesis, KTH Royal Institute of Technology Department of Civil and Architectural Engineering Division of Building Materials Stockholm.

Flexner B & Press R. 2010. *Understanding wood finishing*, American Woodworker

Herrera R, Muszynska M, Krystofiak T & Labidi J. 2015. Comparative evaluation of different thermally modified wood samples finishing with UV-curable and waterborne coatings. *Applied Surface Sciences*, 357, 1444–1453.

Jeff J. 2000. Tools & Materials, Selecting a finish, *FineWoodworking*, 141, The Taunton Press Inc.

Kudela J & Liptakova E. 2006. Adhesion of coating materials to wood. *Journal of Adhesion Science and Technology*, 20, 875–895.

Lambourne R & Strivens TA. 1999. *Paint and Surface Coatings*, Woodhead Publishing Ltd, Abington Hall, Abington, Cambridge CB1 6AH, England .

Liptakova E, Kudela J, Basil Z & Spirovova I. 1995. Influence of mechanical surface treatment of wood on the wetting process. *Mechanical Surface Treatment of Wood*, 49, 369–375.

Meijer M. 2001. Review on the durability of exterior wood coatings with reduced voc- content. *Progress in Organic Coatings*, 43, 217–225.

Mirela VC, Bernard R & Pierre B. 2011. Effect of addition of nanosized uv absorbers on the physico-mechanical and thermal properties of exterior waterborne stain for wood. *Progress in Organic Coatings*, 72, 755–762.

Soderberg George A. 1969. Finishing Technology, McKnight & McKnight Publishing Company Viitanen H, Toratti T, Makkonen L, Peuhkuri R, Ojanen T, Ruokolainen L & Raisanen J. 2010. Towards modelling of decay risk of wooden materials. *Eur. J. Wood Prod*, 68, 303–313.
Wicks ZW, Frank JN, Jones & Peter S. 2007. *Organic Coatings:Science and Technology, Third Edition.*

Wood coating is one of the necessary processes required by the wood-based industry for the purpose of decoration or protection. There are many types of coatings which are defined by how they are cured: evaporative, reactive or coalescing. Several techniques of coatings are available that include brushing, curtaining, dipping, flowing, spraying and 'rollering' which each has its own advantages and disadvantages. The performance of wood after coating can be determined by doing some testing such as abrasion, impact resistance, adhesion, scratch, dry heat, temperature-change and household chemicals tests. The selection of correct coatings type, proper coating technique and understanding well the properties of wood are important to produce high quality coated wood.

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