"WHY WOOD IS SUCH A DIFFICULT SUBSTRATE AND HOW TO PROTECT IT"

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"Why Wood is such a difficult Substrate and how to Protect it"

Outline

Introduction & Trends

- Introduction & About your Speaker
- Company Knowledge
- Your Feedback and Industry thoughts
- Expectations for Today

Wood as a Substrate

- From forest to processing
- Characterization
- Wood vs. Wood Composites
- Main applications

Wood Protection

- All-year-round formulation
- Performance results

Your Speaker

Latoska N. Price, M.S.

Latoska N. Price, Regional Technical Service Mgr, Americas at Synthomer, has worked in the Coatings Industry for over 20 years in the areas of Automotive, Industrial, Architectural and Color Science. Currently, she manages the Technical Service team for the Americas and also, serves as a Technical contact working closely with Coatings customers to develop and support new and existing business.

Latoska earned her B.S. Chemistry from University of Detroit –Mercy and an M. S. Polymer Technology from Eastern Michigan University.

Synthomer Introduction

A growing supplier of specialty polymers

- **A Top 5 Global Supplier of emulsion and specialty polymers with ~ $3 bn of sales**
- **38 production sites in 24 geographies, 9 technical centres globally, sales across all geographies to over 6000 customers**
- **A strong track record of organic growth and M&A**
- **Approximately 4750 employees world-wide**
- **Listed on London Stock Exchange**

"Why Wood is such a difficult Substrate and how to Protect it"

Introduction

Wood

- Wood trim used to cover transitions between surfaces or for decoration
- Surface material for walls, ceilings, floors and stairs (Interiors)
- Used for wood shutters, headers, siding, decks and entry doors (Exterior)

Wood paints

- General shift from solvent-borne to water-borne in most architectural or decorative coatings applications for environmental and/or regulation reasons

Solvent borne wood trim paints

- Continue to exist, and their use is still permitted despite **VOC** regulations and environmental labels
- Widely recognized that no high performance alternative exists at present, especially those for exterior use

Water based coatings

- Attractive from an environmental, toxicological, health and safety point of view
- Water also the main reason for many of the problems that exist with water-borne technology and which has slowed the replacement of traditional solvent-borne paints

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Wood composites

Plywood	→ Sheets of cross-laminated veneer and bonded with heat cured moisture-resistant adhesives → One of the most common wood composites
Medium Density Fiber board	→ Made by breaking down hardwood or softwood residuals into wood fibers combining it with wax and resin, and then applying high temperature and pressure to create panels
Oriented Strand Board	→ Strands of wood arranged in layers and bonded together using moisture-resistant adhesive creating a panel with strength and rigidity
Laminated Timber	→ Layers of engineered wood glued together with structural adhesives → Create various sizes and shapes that can be fabricated to give the appearance of natural wood

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Wood - A complex substrate (1/2)

Environmentally sustainable product…

- Biodegradable and renewable
- Lowest carbon footprint of any comparable building material
- No high-energy fossil fuels required to produce wood, unlike other common building materials

…with unique properties

Cellulose	*Hemicellulose*	*Lignin*
30 – 50 %	*15 – 35 %*	*20 – 35 %*

- **Strong** in relation to its weight
- **Heterogeneous organic** product made of:
- **Lignin:** branched aromatic-aliphatic polyether, considered as the “cement” that binds the cellulose fibers together
- Wood also contains **other minor constituents**: *fatty acids, waxes, albumin, sugars, terpenes, resins, colorants, tannins, alkaloids and mineral substances.*
- **Wood** can be **classified** according to its **hardness/density**
  - **Very soft and soft:** spruce, fir, maple, birch, cedar, poplar and willow
  - **Moderately hard:** elm, pine, chestnut
  - **Hard and very hard:** oak, ash, pear wood, teak, beech, hickory, rosewood, walnut, ebony

Wood trim typically uses softwoods such as pine, fir, birch and cedar

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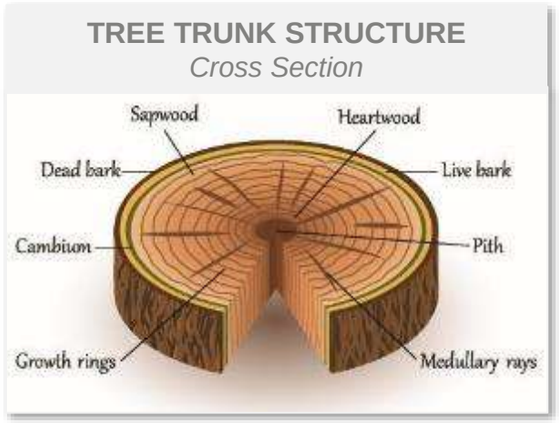
Wood - A complex substrate (2/2)



A “living” substrate

- **Each year’s growth forms a ring consisting of two bands.**
- **Early wood:** light-colored band directed towards the center, formed of large cells developed at the beginning of the cambium growth.
- **Late wood:** darker band directed towards the bark, formed of very small, tight cells developed at the end of the summer.
- **Vascular or medullary rays** (cellular channels radiating from the core to the bark) and resin channels, arranged vertically for the circulation of the sap.

Wood cut: differences in grain, grain direction and texture

Plain sawn wood

- Most common and least expensive.
- Tangential grain, with the annular rings at around 30° to the face of the board. This cut also has the highest tendency to warp.

Rift sawn wood

- Least common and most expensive cut.
- Very dimensionally stable, with the annular rings being optimally at 45° to the face of the board, and having a unique linear grain pattern.

Directional cutting of wood and its effect on grain structure

***Illustrations Credit**: Shutterstock*

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Surface and weather tolerance

Aesthetics, protection, and functionality

- Wood “moves” as a result of **absorption/desorption of water**
- Coatings must be **resistant to external physical, chemical and biological influences**
- A wood coating system must resist **moisture**, grain **cracking, blistering**, stain bleeding, **UV** light
- **Additional requirements:** ease of application, leveling properties, blocking resistance

Surface tolerance

- Very difficult or expensive to **properly prepare the surface**
- **Good adhesion** to surfaces with less-than-ideal surface preparation
- Surface tolerance **important in renovation**: old layers of paint, freshly sanded wood

Weather tolerance

- Application, drying and coalescing conditions depend on **temperature, relative humidity** and **ventilation**
- Ideally, application between **40 to 60% relative humidity and 10 to 40 °C**
- **An extended application window** allows for more convenience and more flexibility in application (early rain, cold weather), saving time, and providing better cost-in-use.

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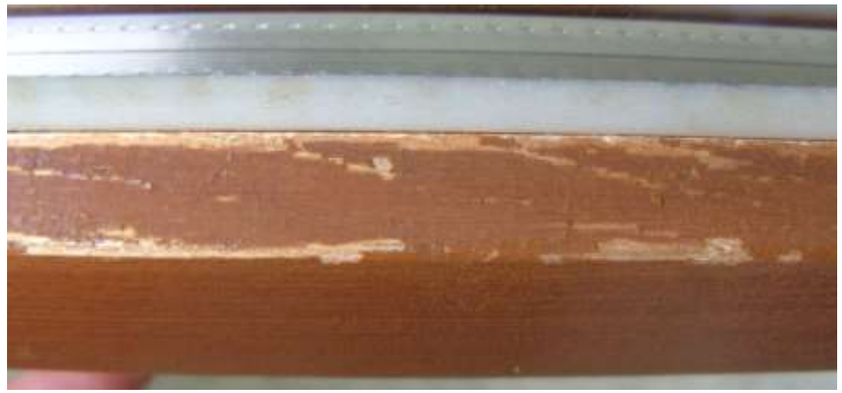
Exposure damages - Delamination

Crack Formations & Flaking

- Thermo-mechanical stress
- Moisture take-up and release
- Coating film is severely damaged

Risk of fungal and Mold Attack

- Exposed Wood substrate



Appearance

- Unattractive
- Time consuming refurbishment

Benchmarking

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Benchmarking

Raw Materials	Lbs.	Gallons
Water	64.4	7.69
Add and allow to mix 15 min.		
Neutralizingagent	2.7	0.32
Dispersing agent	10.7	1.21
Anti-foam agent	0.8	0.10
Titanium dioxide	240.9	7.04
Modified alumina-silicate extender	5.3	0.32
Calcium carbonate	42.8	1.90
Disperse at high speed then add		
Latex A	**623.7**	**71.85**
Anti-foam agent	0.8	0.10
Coalescing aid	9.7	1.22
Associative thickener	23.5	2.82
Anti-Flashrust	5.3	0.56
In-can preservative	0.2	0.02
Water	40.5	4.85
Total	**1071.3**	**100.00**

Characteristics	
Specific gravity	1.29
PVC	23.4%
Weight per Gallon, Lbs	10.7
pH	8.3
Volume solids	40.8%
Weight Solids	54.2%
VOC AIM*	32 g/l
MFFT	< 0°C

FORMULATION FREE OF FUNCTIONAL ADDITIVES TO BETTER ASSESS POLYMER PERFORMANCE

Performance Results

1. Shower resistance
2. Block resistance
3. Aging and weathering
4. Crack test resistance
5. Adhesion on alkyd paint

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Benchmarking

Paint reference	Binder type	Brookfield viscosity *50rpm (cP)*	ICI viscosity *(P)*	MFFT *(°C)*	Gloss at 20° *(GU)*	Gloss at 60° *(GU)*
Commercial **wb1**	Styrene acrylic	10 460	3.5	<-5	5.4	42.3
Commercial **wb2**	Pure acrylic	10 080	4.3	<-5	5.4	33.5
Commercial **wb3**	Pure acrylic	9 960	2.0	<-5	5.4	33.5
Commercial **wb4**	Styrene acrylic	3 140	2.7	-0.5	3.9	24.0
Commercial **sb1**	Alkyd	1 540	4.8	-	59.6	83.6
Commercial **sb2**	Alkyd urethane	3 280	4.0	-	10.1	44.5
FPS 701	***Latex A***	***2 300***	***1.9***	***< -5***	***9.7***	***38.6***

Performance results

Block Resistance

Scope

- To evaluate resistance to blocking when painted surfaces are placed in contact after a short drying time

Test method

- 6 mils wet with a bird applicator on black PVC Leneta card
- Drying of the paint with variation of drying time (1 week or 1 day) and drying conditions (73ºF / 50% RH or 40°F / 90% RH)
- 1 inch strips are cut from the panels and then placed in direct contact with a pressure of 250 lbs./ft^2 during 24 hours at 73 ºF
- Blocking resistance results are rated from 0 (bad) to 10 (excellent) and the percentage of removed paint is also reported.
- Results are the average of 5 trials.

Drying time	1 week		24 hours		
Drying conditions	73ºF / 50%RH		73ºF / 50%RH		40°F / 90%RH
Test conditions	24h at 73ºF	24h at 40°F	24h at 73ºF	24h at 40°F	24h at 73ºF
Commercial **wb1**	10 / 0	9 / 0	10 / 0	7 / 0	7 / 28
Commercial **wb2**	8 / 0	8 / 0	8 / 0	6 / 0	7 / 0
Commercial **wb3**	8 / 0	7 / 0	7 / 0	3 / 64	6 / 50
Commercial **wb4**	9 / 0	6 / 22	6 / 28	5 / 78	6 / 44
Commercial **sb**	10 / 0	8 / 0	9 / 0	5 / 60	7 / 66
FPS 701	**9 / 0**	**9 / 0**	**9 / 1**	**8 / 0**	**8 / 3**

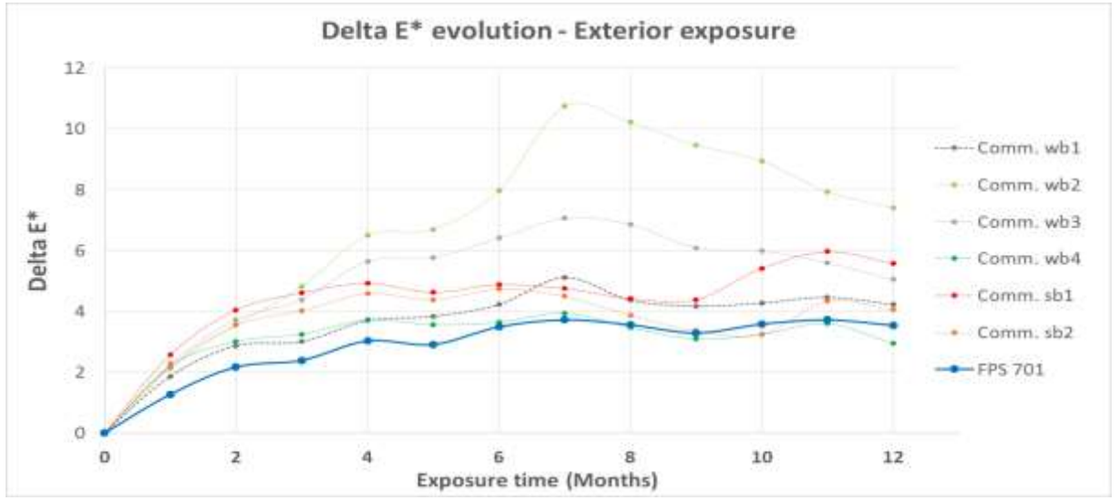
Latex A formulation improves blocking resistance in difficult drying conditions

Performance results

Natural weathering on wood / Outdoor exposure according to EN 927-3

Test method

- 2 x 130g/m² by brush on pine wood, front and sides
- End-grains are sealed
- 7 days of drying at RT
- Every month: ΔE* measurement + panel examination



Results

- Except **wb2**, which shows a strong delta E* before 6 months, all paints demonstrate good color retention
- Nevertheless, paints **wb1** and **wb4** exhibit noticeable cracking, rated respectively as degree5 / class4 and degree3 / class3
- **FPS701** based on **Latex A** demonstrates very good durability : no defects other than a slight dirt pick-up

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Performance results

› Shower test resistance on wood with alkyd paint

Drying before testing	90 min	60 min	45 min	Drying before testing	90 min	60 min	45 min
Commercial wb1		-	-	Commercial wb2		-	-
Commercial wb3			-	Commercial wb5		-	-
Commercial sb1			-	Commercial sb2		-	-
FPS 701							

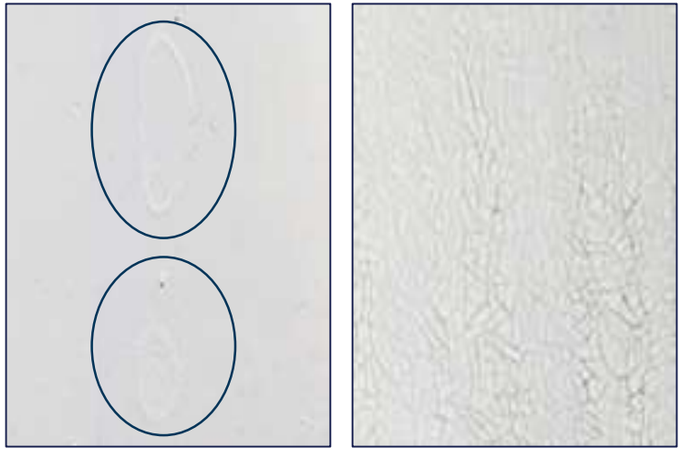

Fig. 1
Surface defects of solvent-based (left) and water-based (right) paints

Comments

- Water impacts **solvent-borne alkyd** paints (Fig. 1)
- All commercial **water-based paints** are damaged even after 90 minutes of drying
- **Wb3** exhibits micro-cracking, indicating poor film formation (Fig.1)
- **Paint formulated with Latex A** demonstrates superior early rain resistance.
- When dried under critical cold and humid conditions, **paint formulated with Latex A** provides the best performance

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Performance results

› **Crack test resistance on wood with alkyd paint**

Scope

- To evaluate the ability of paint to bear the natural variation of the wood during “heating-immersion-freeze-thaw” cycles

Test Method

- 2 coats by brush at 400 sq.ft. per US gallon on all faces +24h drying at RT
- 20 cycles: [4h at RT + 3h at 122°F + 1h in water + 16h at -4°F]

Paint reference	Cycles	Final aspect
Commercial wb1	6	
Commercial wb3	20	
Commercial sb1	20	
FPS 701	20	

Paint reference	Cycles	Final aspect
Commercial wb2	20	
Commercial wb4	20	
Commercial sb2	20	

Cracking resistance of paint formulated with Latex A is equal to the best commercial paints

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Performance results

› Adhesion on alkyd paint

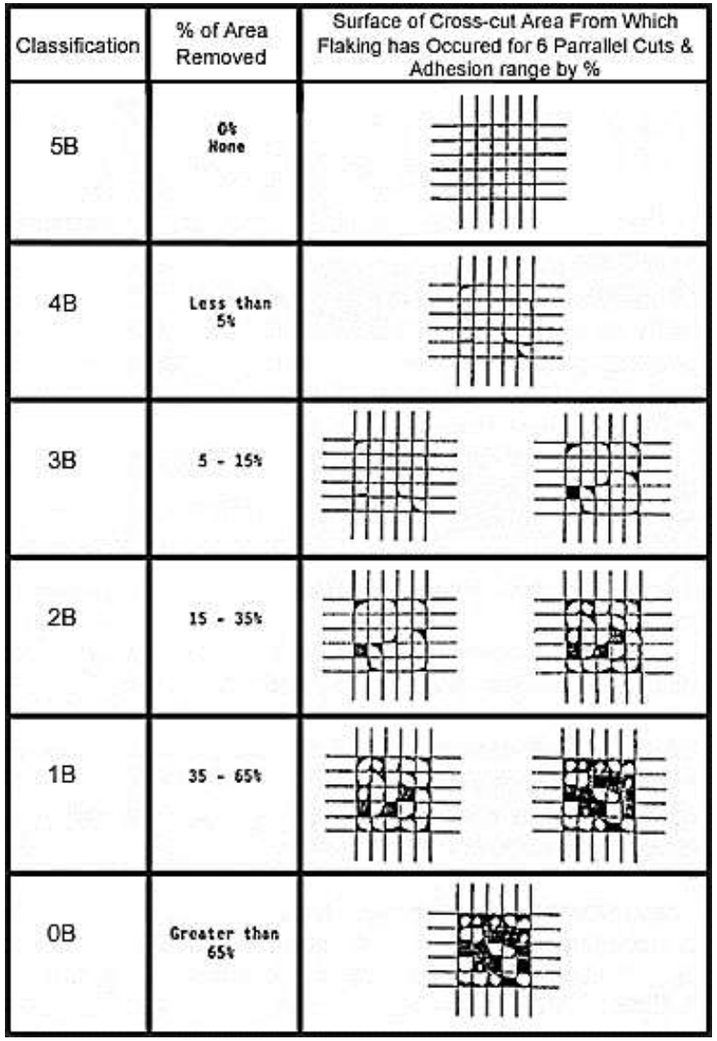
Scope

- To evaluate adhesion performance of paint that could be applied on old woodwork originally painted with alkyd paints

Test Method

- 2 coats by brush of a solvent based alkyd paint on fibrocement panel (24h between each)
  - *5 days of aging at 122°F*
- 2 coats by brush at 400 sq.ft. per US gallon of wood paint to be evaluated
  - *24h and 7 days of drying at RT before cross cut in wet & dry conditions (for wet condition, application is humidified with a wet tissue for 3h)*

Conditions of drying	7 days of drying at 73°F		24h of drying at 73°F	
Conditions of testing	Wet adhesion	Dry adhesion	Wet adhesion	Dry adhesion
Commercial wb1	1B	5B	3B	5B
Commercial wb2	2B / TR*	0B	0B / TR*	0B
Commercial wb3	5B	5B	4B	2B
Commercial wb4	5B	5B	3B	5B
Commercial sb1	5B	5B	3B	4B
Commercial sb2	1B / TR*	0B / TR*	3B / TR*	1B / TR*
FPS 701	**4B**	**5B**	**4B**	**5B**



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Performance results

› Chemical Resistance

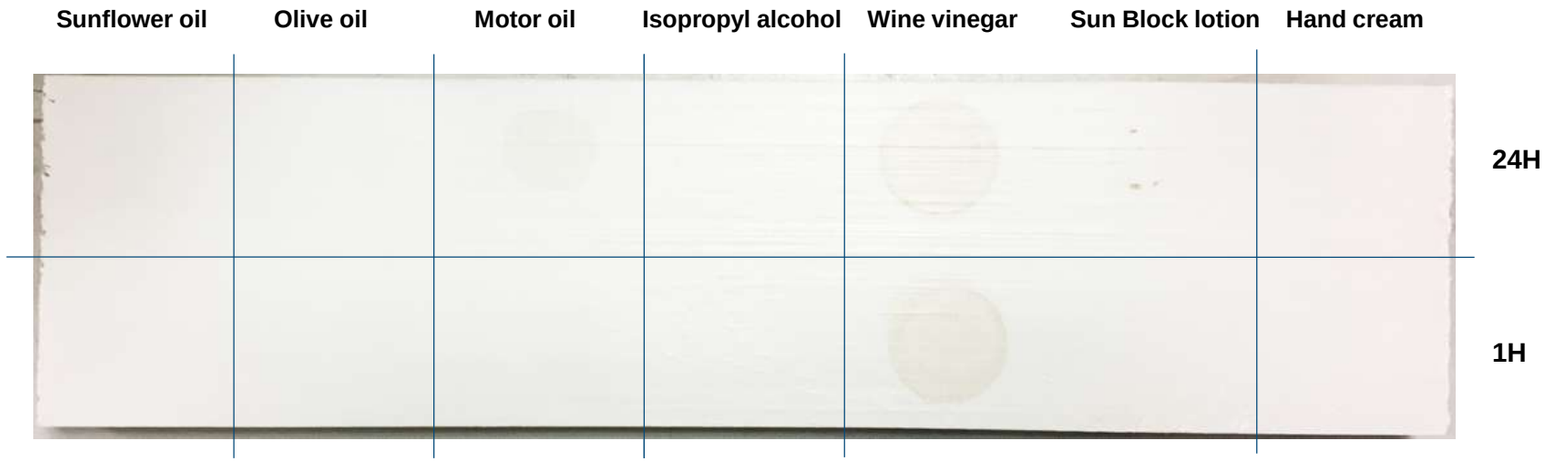
Scope

- Check that the paint is resistant enough to maintain good cohesion and film integrity when subjected to different products

Test Method

- 1 coats by brush at 130g/m² of wood paint to be evaluated
  - *3 days of drying at RT*
- Products are applied and a cap is put on the drop to prevent evaporation. After 1h and 24h, results are expressed by referring to the ranking

Chemical resistance ranking	
0	Flaking, stripping
1	Softening of the film and loss of adhesion
2	Softening of the film, but no loss of adhesion
3	Blistering
4	Discoloration without blistering, neither softening
5	Stain, spotted surface
6	No change



Conditions of testing	1h		24h	
Sunflower oil	**6**		**6**	
Olive oil	**6**		**5**	
Motor oil	**6**		**5**	
Isopropyl alcohol	**6**		**6**	
Wine vinegar	**5**		**5**	
Sun Block lotion	**6**		**1**	
Hand cream	**6**		**6**	

Summary

- Know your Wood substrate! Remember there are many different types
- Adhesion is necessary to minimally prepared surfaces, including aged alkyds
- Achieve blocking resistance after drying at low temperature and high relative humidity
- Good balance of hardness and flexibility to expand application window under different climatic conditions
- Strive for outdoor durability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