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Oligomers for LVT - Enabling Differentiation

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RADTECH UV+EB 2020

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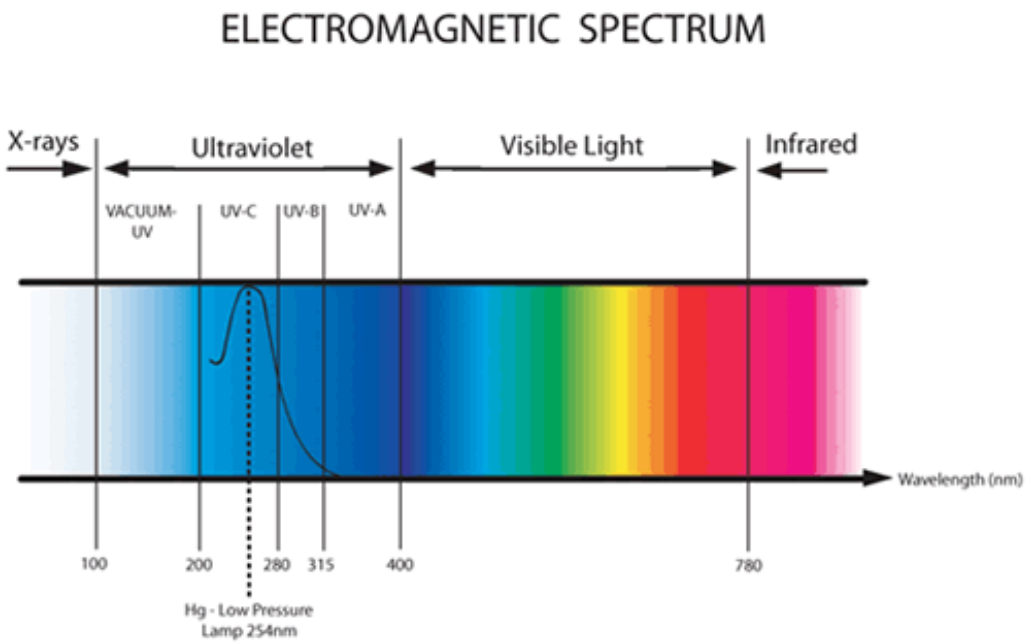
The Coating Resins Company

Background

What is Ultra-Violet (UV) curing?

- Using UV energy or visible light, as opposed to heat, solvent evaporation, or oxidation (air-drying), to convert a liquid formulation into a solid material
- Types of energy used:
  - Ultra Violet (UV): 200 – 400 nm
  - Visible light: typically 380 - 450 nm



Advantages of 100% Solids UV Curable Systems

- Productivity, Productivity, Productivity
  - Seconds to cure vs. minutes or hours
- Lower Overall Cost (per cured part)
  - 100% solids, cure speed, recycling of coating, etc.
- Single component formulas
  - Eliminates mixing errors found in 2 component systems
- Regulatory Concerns (VOC emission)
  - Avoid solvent use in most cases
- Smaller equipment footprint
  - Less floor space needed
- Energy costs

Luxury Vinyl Tile – What is it?

Vinyl Composition Tile (VCT)

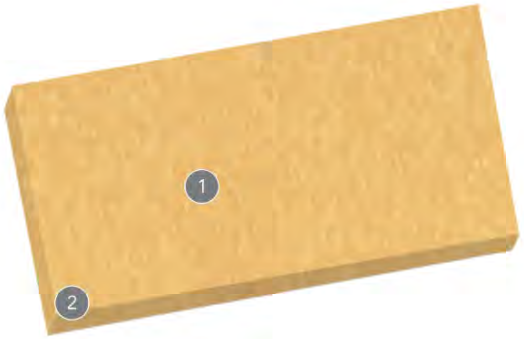
- Mono-layer plus coating (protective layer for installation)
- Wear layer is the entire product
- Available as tiles
- Colors and abstract patterns
- Brittle material with high durability

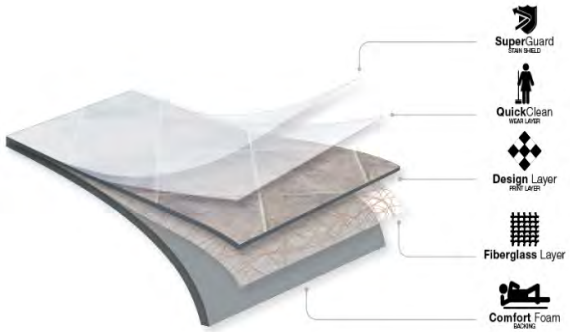
Sheet Vinyl:

- Multi-layered:
  - protective urethane top coat
  - protective clear vinyl layer
  - printed design layer
  - felt or fiberglass backing
- Available in sheets (6-12’ wide)
- Range of colors and designs that can mimic tile or wood
- Can be heterogeneous (multiple layers plied together as described above), or homogeneous (through-body vinyl with protective top coating).

Luxury Vinyl:

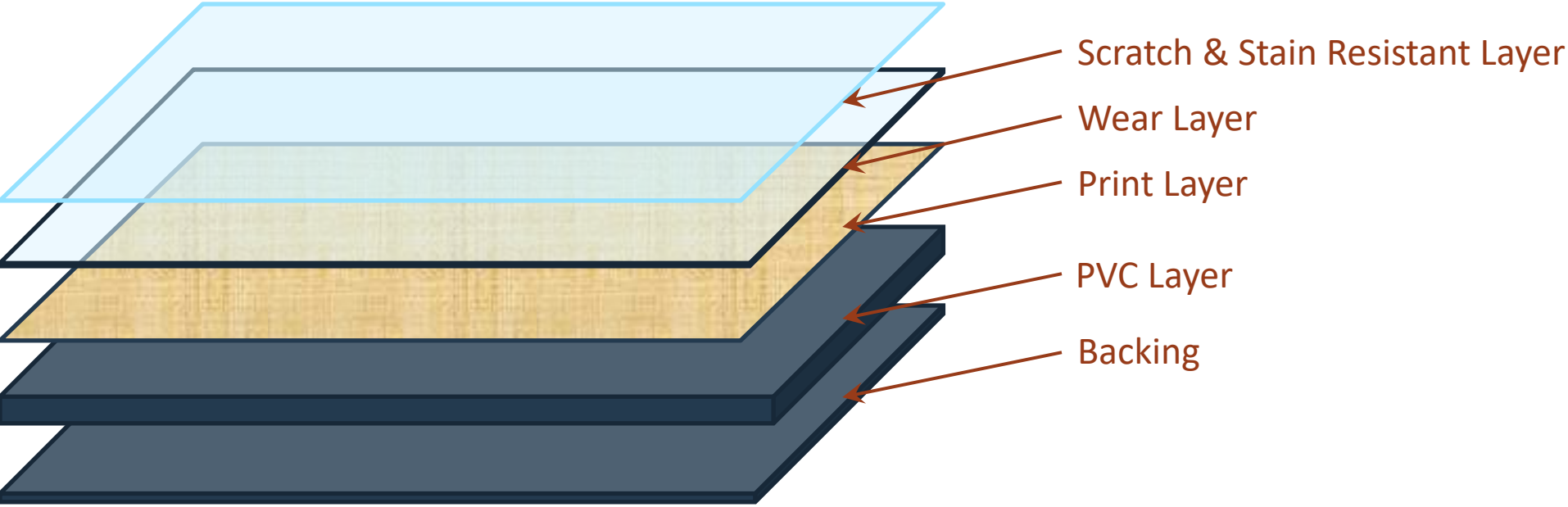
- Multi -layered:
  - core and backing layers
  - high definition printed layer
  - transparent wear layer
  - SARC topcoat
- Available in tiles and planks
- Can be heterogeneous (multiple layers plied together as described above), or homogeneous (through-body vinyl with protective top coating).



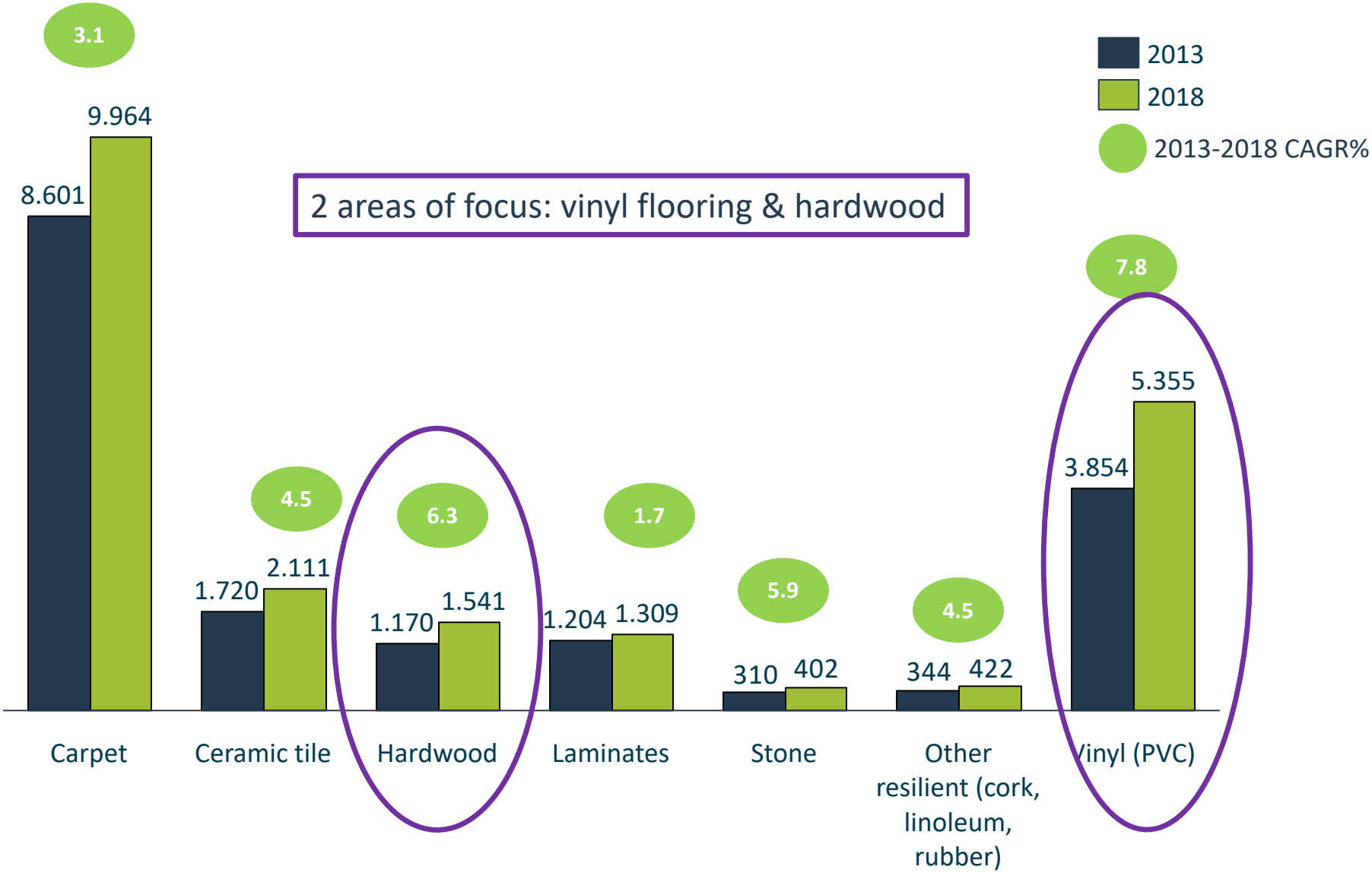


Luxury Vinyl Tile – What is it?

- Luxury vinyl tile (LVT) is one of many types of resilient flooring, characterized by its successful combination of aesthetics and performance.
- LVT uses the latest 3D imaging technologies and embossing to replicate real hardwoods and stones to the point where it is often difficult to distinguish between real wood or stone and LVT.
- LVT is comprised of multiple layers of material, and usually includes one or two layers of PVC as the foundation, a photographic image layer, a wear layer and a scratch and stain resistant topcoat.
- This construction makes LVT a very durable flooring material.
- LVT is typically thinner than most hardwood planks, stone, or ceramic tiles and can be glued down or floated – a relatively easy process, particularly for do-it-yourselfers.
- The final product is both affordable and easy to maintain.



Luxury Vinyl Tile – Why Focus on It?



Luxury Vinyl Tile – Why Focus on Differentiation

- From end-user standpoint, LVT is meeting their needs
- Many customers search on-line, so small differences in product performance can sway the consumer
- LVT manufacturers need to differentiate from one another
- Resin suppliers must be able to deliver oligomers that can enable differentiation in LVT coating formulations

- Look at 2 areas:
  - Improvements in scratch/stain resistance
  - Improvements in white gouge visibility reduction

Resins for Improved Scratch & Stain Resistance

Formulation:

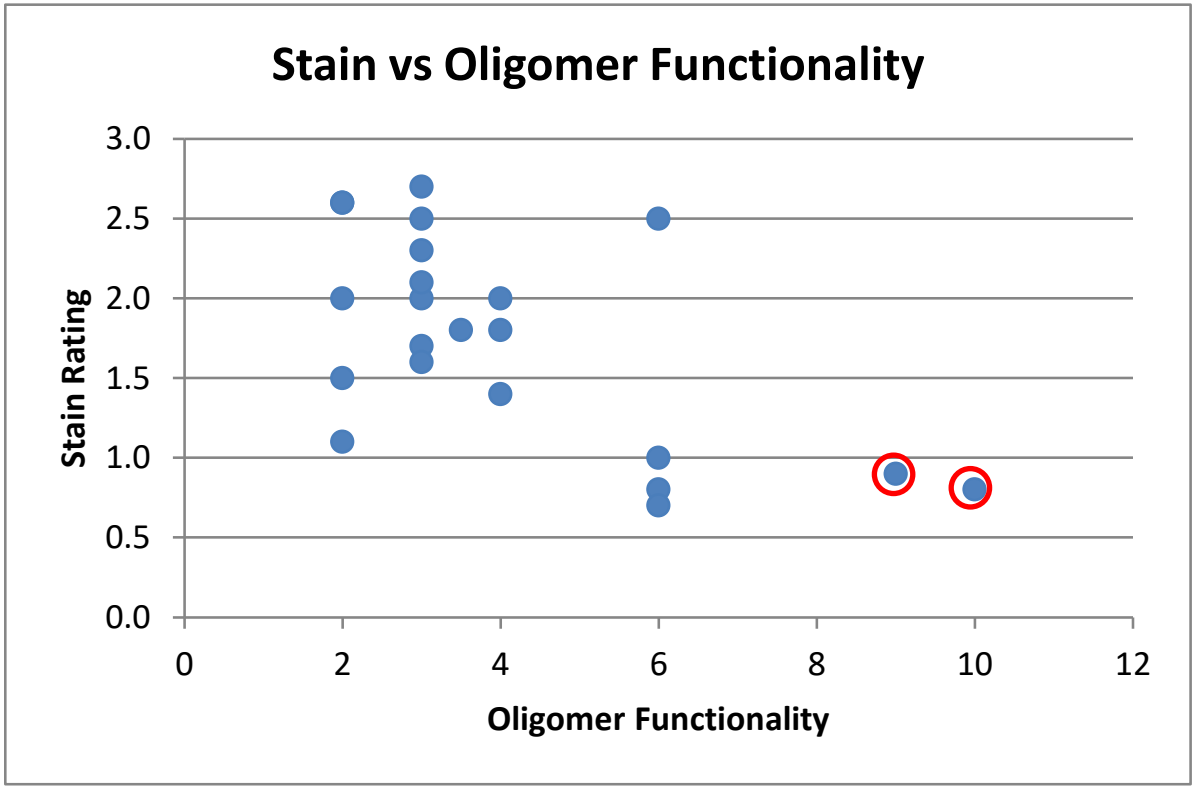
RM	Parts
Oligomer	40
Monoacrylate diluent	20
TMPTA	5
TPGDA	as needed to hit 750 cps +/- 50
Silica	6
Amine synergist	3
Photoinitiator	3

Coating Preparation:

Parameter:	Value:
Substrate:	“Chalk” colored VCT substrate
Dry Film Thickness:	1 Mil
Energy Density:	700 ± 40 mJ/cm2
Sample Viscosity:	750 ± 90 cps
Draw Down Tool:	1 Mil Bird Bar, 6" Length

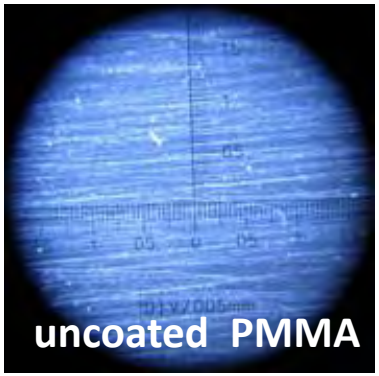
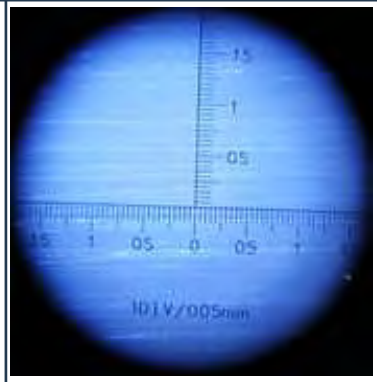
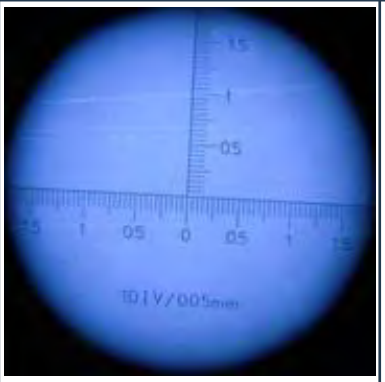
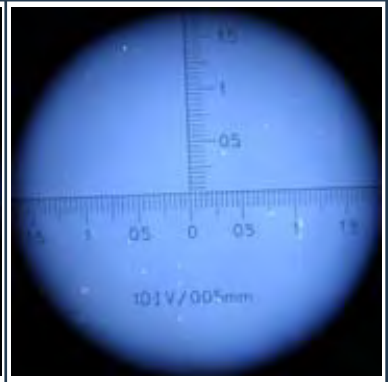
Resins for Improved Scratch & Stain Resistance

- 23 resins initially screened
  - 11 aliphatic UA
  - 5 aromatic UA
  - 5 PEA
  - 1 Modified EA
- Functionality ranged from 2 – 10
- Higher functionality > best stain resistance



Stain
Lugol's Iodine Solution
Wright's Stain
Betadine
Black RIT Dye
Ketchup
Mustard
Antiseptic Solution
Blue Food Coloring (blue, red)
Coffee
50% Ethanol Solution
Bleach
Sharpie Markers (red, blue, green, black)
Kiwi Brown Shoe Polish
Coal Tar
Vinegar
Water

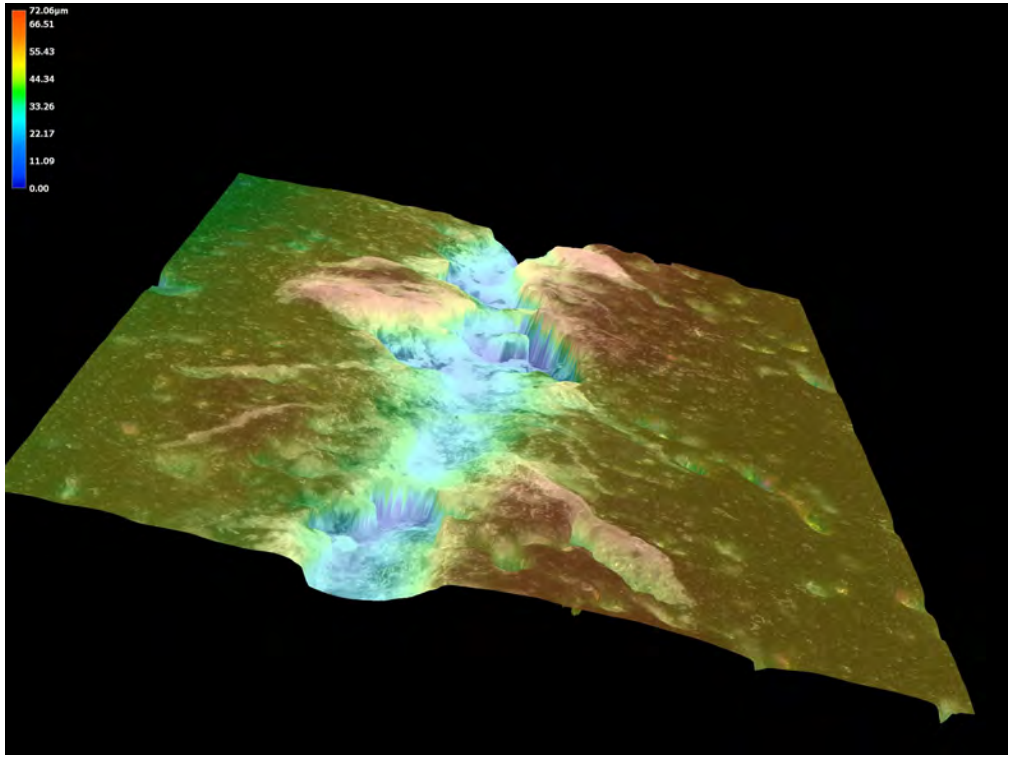
Resins for Improved Scratch & Stain Resistance

	6f ALUA	9f ALUA	10f ALUA
100 acetone double rubs	OK	OK	OK
Cross hatch tape adhesion	100 %	100 %	100 %
Visual inspection (µscope) (10 DR, 00 steel wool)	lots of scratches	some scratches	very few scratches
 uncoated PMMA			

1 mm

Resins for Reducing White Gouge Visibility

- White gouge does not refer to surface scratches but rather to deep scoring of the LVT that is likely not preventable by the coating
- The scoring produces a highly visible white mark
- Goal is to reduce the visibility of the white mark



Resins for Reducing White Gouge Visibility

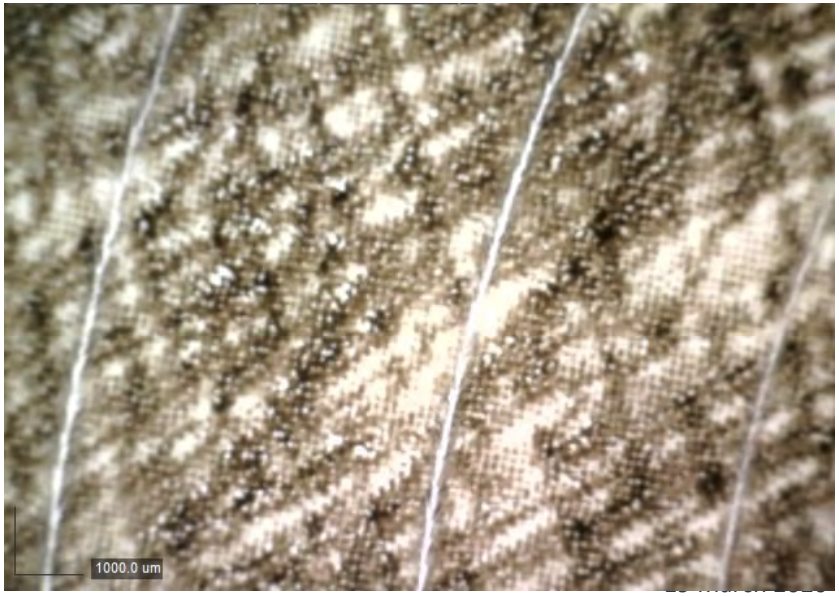
- Reproducibly produce white gouge using Taber Shear Scratch Tester mode 502

- Substrate was uncoated LVT generously donated from a variety of formulators and LVT manufacturers
- DFT ~ 1 mil
- Cure conditions: 600 WPI Hg lamp raised 3” from focal distance (energy density ~ 1,100 mJ/cm^2, irradiance ~ 1.3 W/cm$^{2)}$

Resins for Reducing White Gouge Visibility

ORIGINAL SPF	
Resins	**Parts**
ALUA 1	16.5
ALUA 2	14
HDDA	34
TMPTA	3
Photoinitiator	6.5
Dispersant	4.0
Silicas	15.1
Waxes	7.5

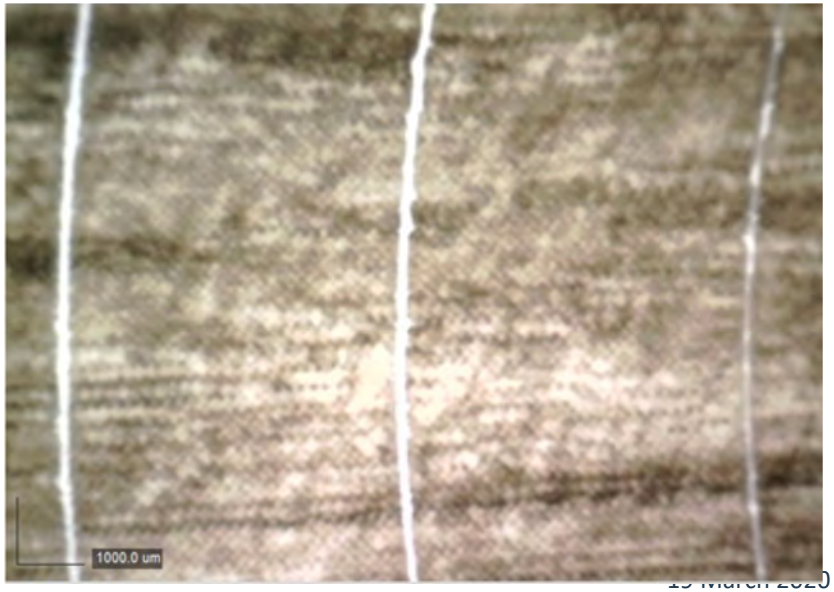
- Whitening is visible with naked eye with 750 and 1,000 grams
- Cracking and fillers were visible on optical microscope.
- Brittle coating, highly crosslinked coating



Resins for Reducing White Gouge Visibility

ORIGINAL SPF		A
Resins	Parts	Parts
ALUA 1	16.5	
ALUA 2	14	14
ALUA 3		16.5
HDDA	34	34
TMPTA	3	3
Photoinitiator	6.5	6.5
Dispersant	4.0	4.0
Silicas	15.1	15.1
Waxes	7.5	7.5

- Replace hard 6f UA with lower func ALUA 3 to reduce brittleness
- No cracking along gouge, narrower lines, less visible
- Slight decrease in surface hardness (sclerometer 16N to 14N)
- Little change in stain resistance

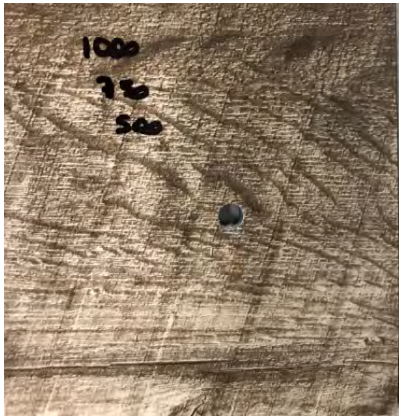


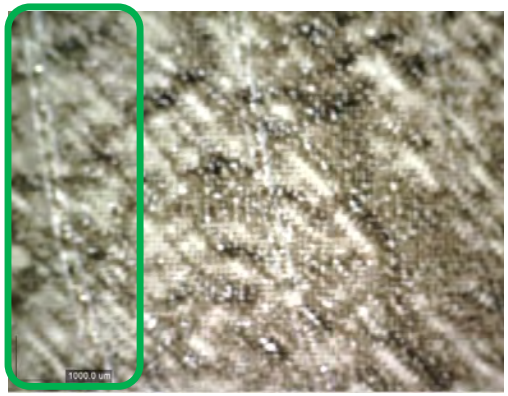
Resins for Reducing White Gouge Visibility

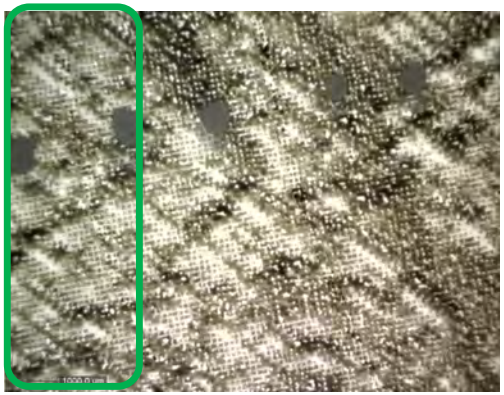
ORIGINAL SPF		A	B
Resins	Parts	Parts	Parts
ALUA 1	16.5		
ALUA 2	14	14	15
ALUA 3		16.5	15
ALUA 4			5
HDDA	34	34	17
TMPTA	3	3	
Diluent 1			10
Diluent 2			5
Photoinitiator	6.5	6.5	6.5
Dispersant	4.0	4.0	4.0
Silicas	15.1	15.1	15.1
Waxes	7.5	7.5	7.5

Before hot air.

After hot air (30 sec, hair dryer)







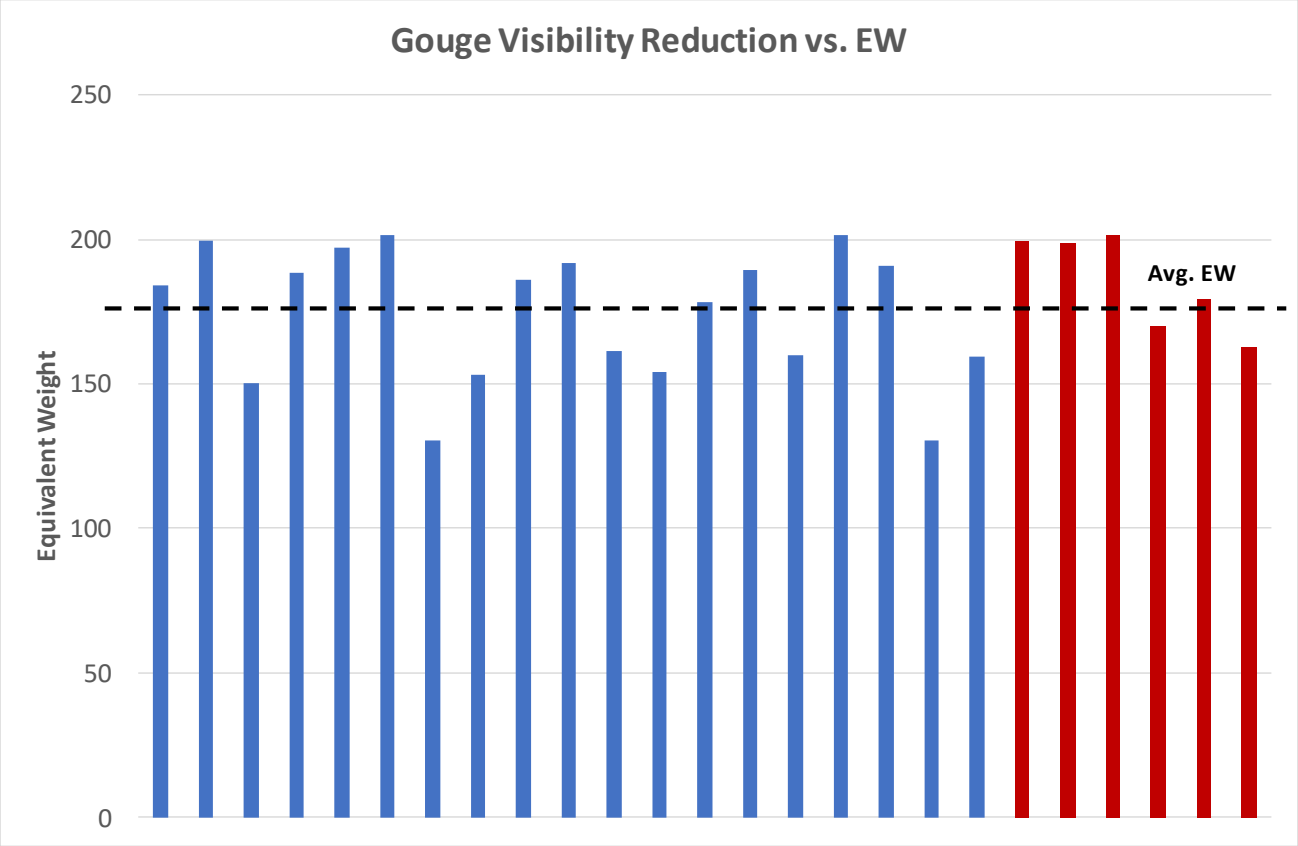
- Replace hard 6f UA with lower func ALUA 3 and ALUA 4 to reduce brittleness. New diluents added.
- Whiteness disappears after 30 sec under hot air from hair dryer (gouge is still there, just hard to see)
- Decrease in surface hardness (sclerometer 10N)
- Stain resistance decreases

Resins for Reducing White Gouge Visibility

- Attempt to identify properties associated with good white gouge visibility reduction
  - Equivalent Weight
  - Tg

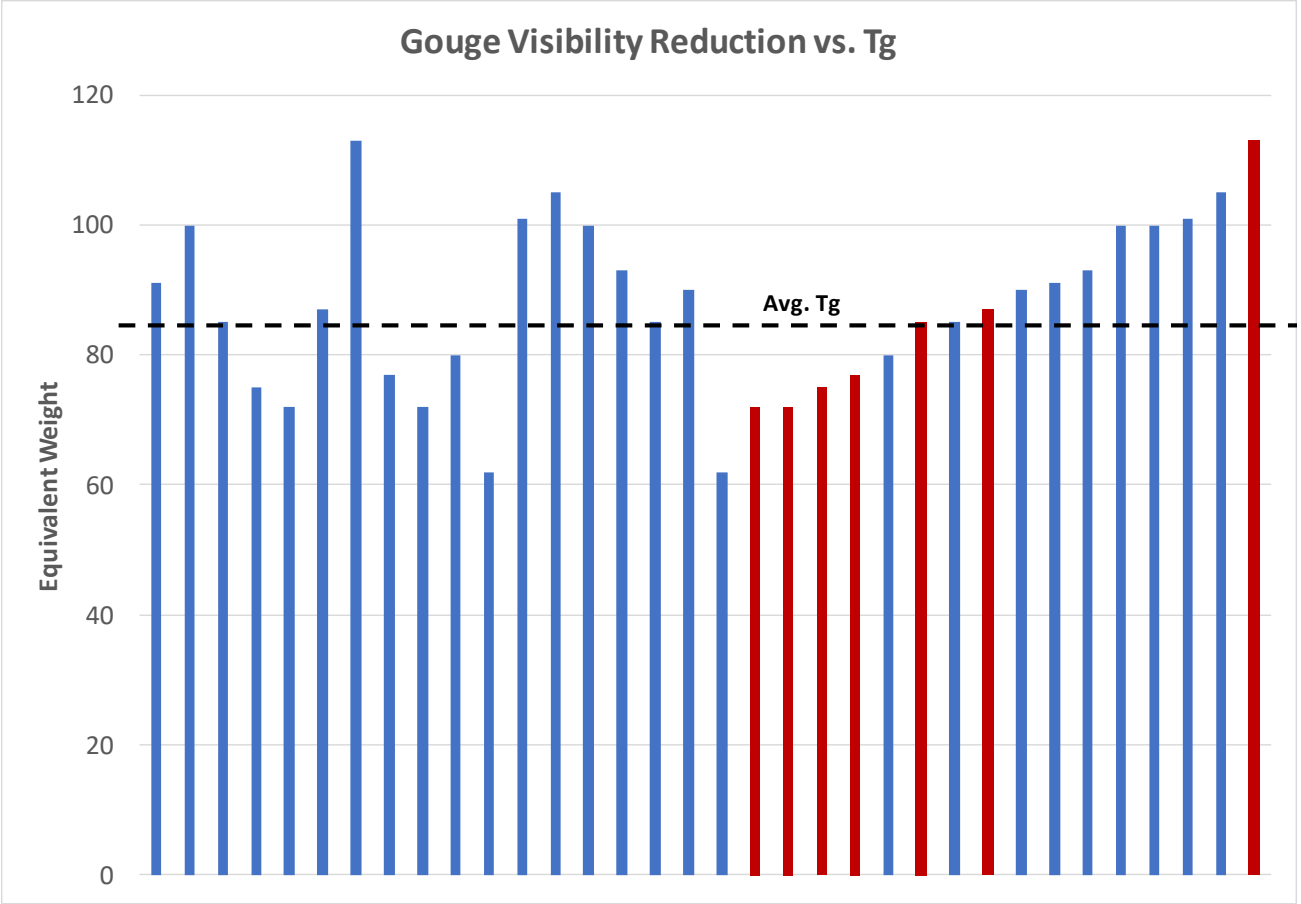
Resins for Reducing White Gouge Visibility

- Equivalent Weight
  - Formulations with good visibility reduction tend to have higher EW, but other with same or higher EW do NOT exhibit the phenomenon



Resins for Reducing White Gouge Visibility

- Glass Transition Temperature
  - Formulations with good visibility reduction tend to have lower Tg, but other with same or lower Tg do NOT exhibit the phenomenon



Resins for Reducing White Gouge Visibility - Conclusions

- Identified 4 oligomers (ALUA 2, 3, 4, 5) and 1 diluent (plus HDDA/TMPTA) that can be formulated to give coatings with reduced white gouge visibility after heating with hot air
- We cannot correlate the effect with EW or Tg
- Improved white gouge visibility reduction is accompanied by some degree of reduction in surface hardness and/or stain resistance (trade-offs exist)
- Continuing to look at structural features and physical properties to determine which are important to generating the effect

Acknowledgements

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Thank you

Visit allnex at Booth #301

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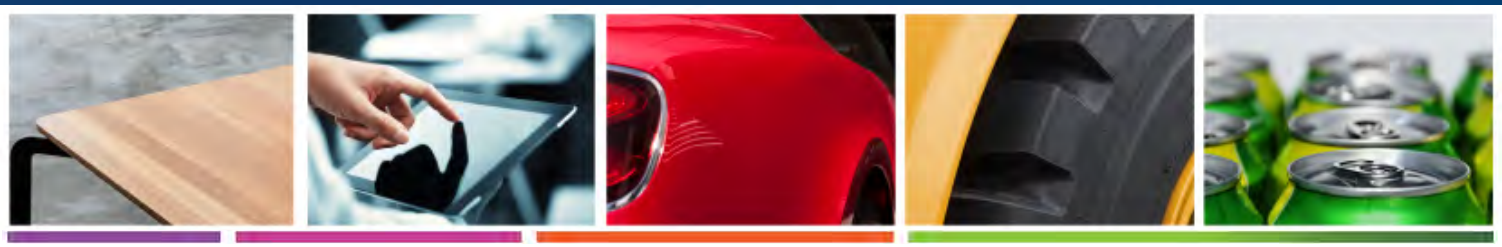

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