AMERICAN COATINGS SHOW+ CONFERENCE

Aluminum Oxide Nanocomposite Wax Powders as PTFE Replacements

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High Performance Wax Additives

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Presentation objectives

- Understand how wax functions in a coating
- Describe how a composite wax is designed and manufactured
- Introduce new nanocomposite wax technology based on modification with aluminum oxide
- Show how these waxes can replace PTFE
  - REACH (EU) 2017/1000

Data to be presented

- Performance of nanocomposite waxes vs. conventional waxes
  - Scratch resistance
- Efficiency of alumina nanocomposite waxes vs. free aluminum oxide
- Performance of nanocomposite waxes vs. PTFE waxes

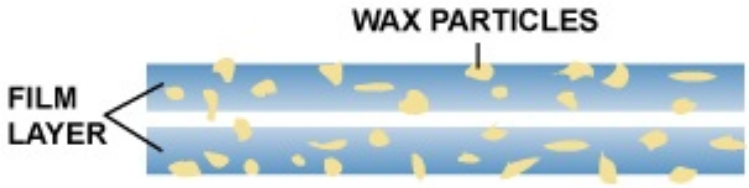
Wax performance categories

- Surface durability
  - abrasion, slip, rub, scratch resistance, burnish/polishing
- Matting and gloss reduction
- Water repellency and beading
- Tactile properties
  - Texture, soft touch, silky feel
- Special effects (colored particles)

In order to fully appreciate the value of composite wax technology, you first need to understand:

How Wax Works

How wax works



- Wax additives are only effective if they can get to the surface of a cured coating
- How does wax get to a surface?
- A combination of
  - Particle movement associated with evaporation of solvent/water
  - Film shrinkage that exposes particles
    - Evaporation or absorption/penetration of volatiles

Why is this important?

- Wax efficiency (the ability of a micro-fine particle to get to the surface) governs performance and dosage rate
- Wax particles with lower density require less energy to get to the surface
- Understanding this principle, waxes can be engineered for maximum efficiency

What this means to you

- A more efficient wax additive may be more expensive . . .
- But if it gets to the surface more completely
  - Wax that is not at the surface of a coating is wasted
- Often allows the formulator to use a lower dosage vs. a less expensive additive
- **Higher cost, higher performance wax additives can actually *lower* formulation cost**

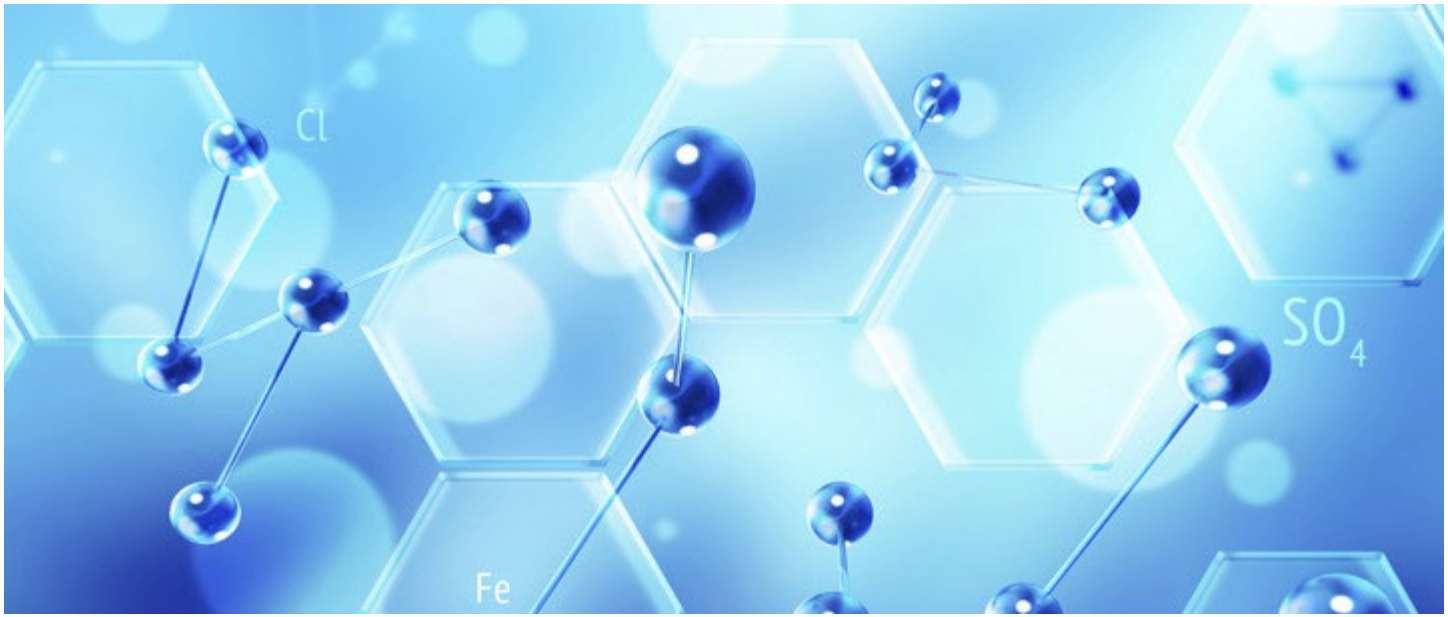
Important properties of wax

- Particle size
  - Mean particle size & maximum particle size
- Wax type
  - Different wax polymers give different effects
- Melting/softening point
  - Especially important in high temperature applications
- Wax density
  - How will the wax particle behave in your coating system?

Wax density

- Wax density can be
  - As low as 0.89 g/cc
  - As high as 2.2 g/cc
- Wax particles obey the laws of gravity
  - If a wax particle has a density lower than that of your coating system, they will want to float
  - If the density is higher, they will want to sink
- Optimized wax particle density provides maximum formulation efficiency (more particles at the surface)

Wax Composite Technology



What is a composite wax?

- A micronized powder manufactured using a solid melted matrix of two or more different waxes or other functional components
- *NOT* a mixture of two micronized powders
- Composite waxes provide unique performance not achievable by mixing the separate components together

Polyethylene/PTFE composite

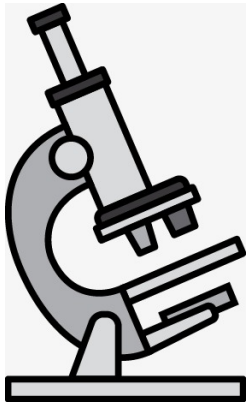
- Melt high density polyethylene wax with microfine PTFE, and then micronize the composite material
- Composite particle is now lighter (less dense) than 100% PTFE
  - 1.07 vs. 2.2 grams/cc
- And is therefore more efficient
  - Easier to get to the coating surface
  - Less likely to settle

Better efficiency enables a lower wax dosage

Polypropylene/$CaCO_3$ composite

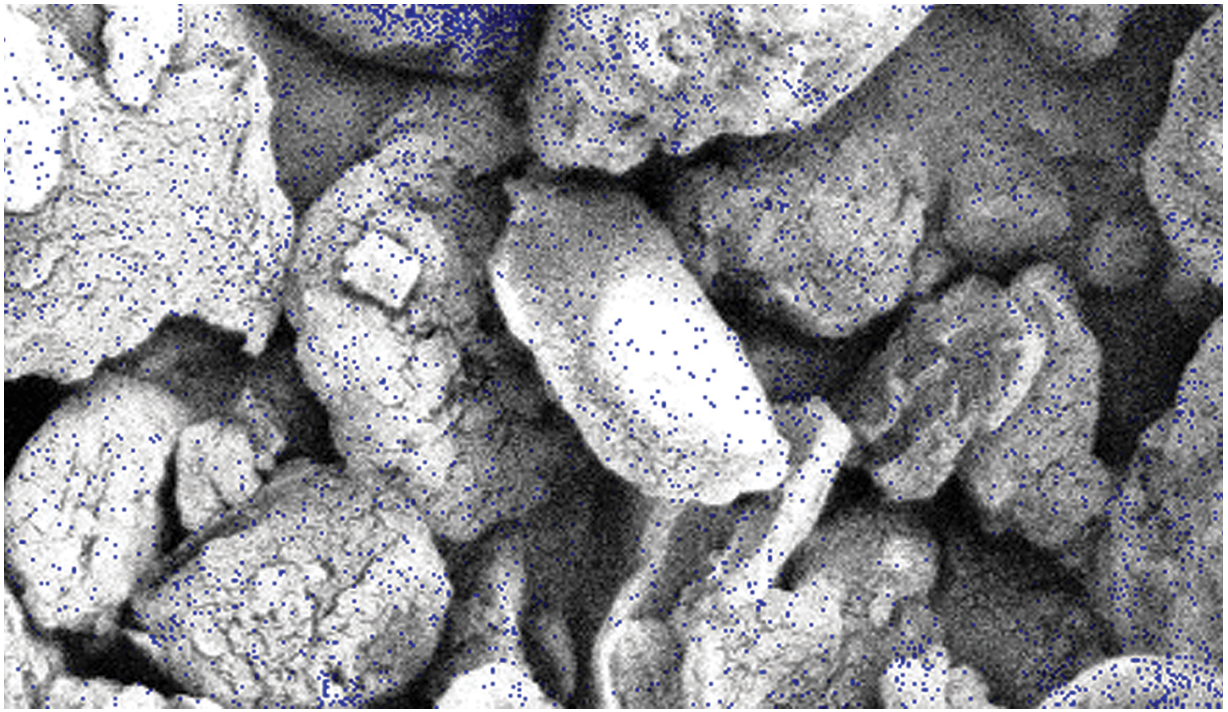
- Melt polypropylene wax with calcium carbonate, and then micronize the composite material
- Composite particle is now heavier (more dense) than 100% polypropylene
  - 1.07 vs. 0.89 grams/cc
- And is therefore more efficient
  - Less likely to float in a water based or UV formulation
  - Good mobility to get to the surface

Composite particle morphology



- Combine analytical techniques
  - Scanning Electron Microscopy (**SEM**)
    - To image the individual composite particles
  - Energy Dispersive X-ray Micro-Analysis (**EDX**)
    - To detect & map the presence of specific elements
- SEM-EDX allow us to both image and capture the morphology of our wax particles as well as to differentiate PTFE domains from PE domains in our melt blended wax composite materials

SEM/EDX image of PE/PTFE composite wax



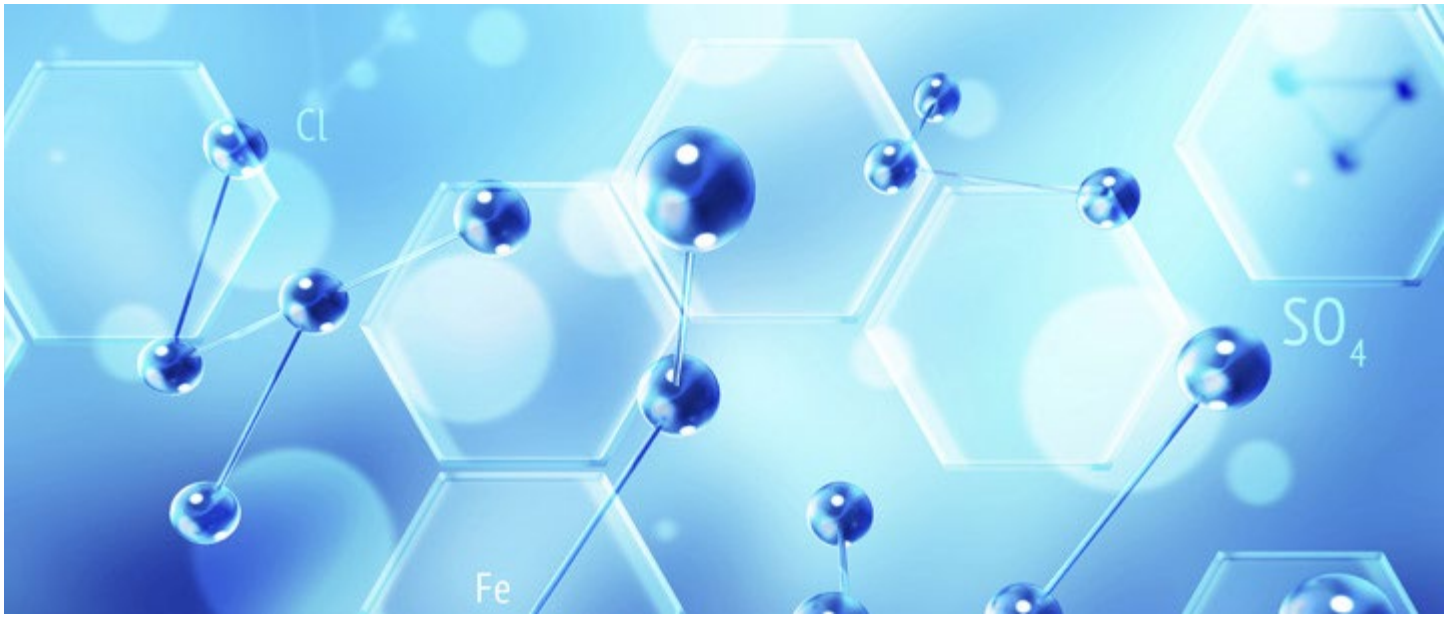
Fluorine-rich domains (from PTFE) are imaged in **blue**

Each particle contains both PE and PTFE

Unique composite products

- HDPE (or LDPE)/ceramic microspheres
  - Hard, inert ceramic particles
  - Maximum Taber abrasion
- Polypropylene/PTFE
  - PTFE densifies the polypropylene
    - less flotation in water based and/or UV systems
  - Adds slip and abrasion resistance to the polypropylene

Wax Nanocomposite Technology



Benefits of aluminum oxide

- Aluminum oxide nanopowders have been used successfully to dramatically improve scratch and abrasion resistance
  - High performance flooring
- BUT the use of nanopowders in coatings presents a number of challenges . . .

The problems with nanomaterials

- Nanoparticles are extremely difficult to wet and disperse into coatings
- Nanomaterials are dusty and difficult to handle
- Nanomaterials have been associated with potential health issues if aspirated
- The solution:
  - Incorporate the nanomaterial into a composite wax powder

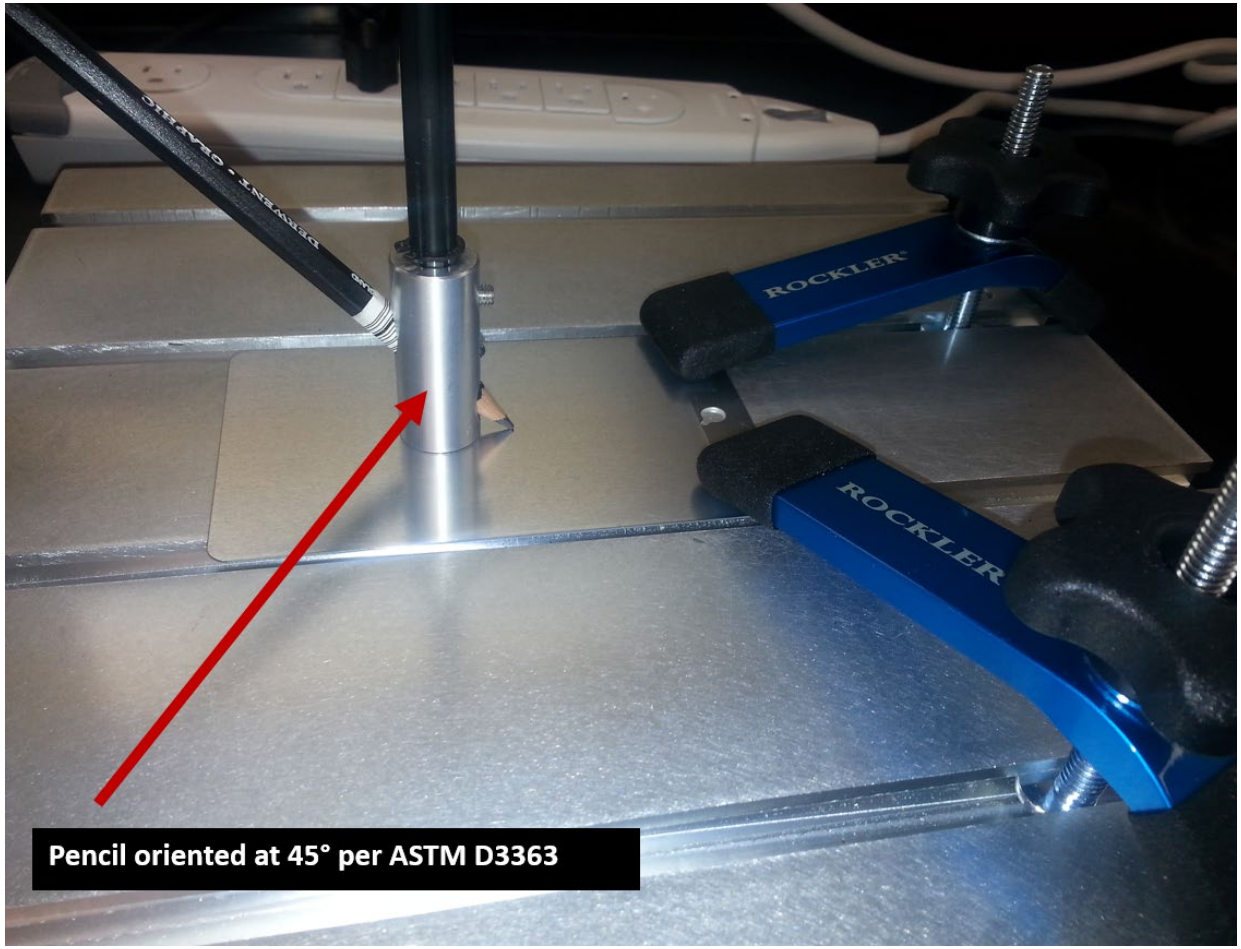
Nanocomposite Wax 611

- HDPE/alumina nanocomposite
  - Micronized melt composite of HDPE and submicron aluminum oxide
  - Mean particle size 4.0 – 6.0 µm
  - Maximum particle size 15.56 µm
    - Can and container coatings (175.300 compliant)
- Scratch and abrasion resistance with lubricity and slip; PTFE free

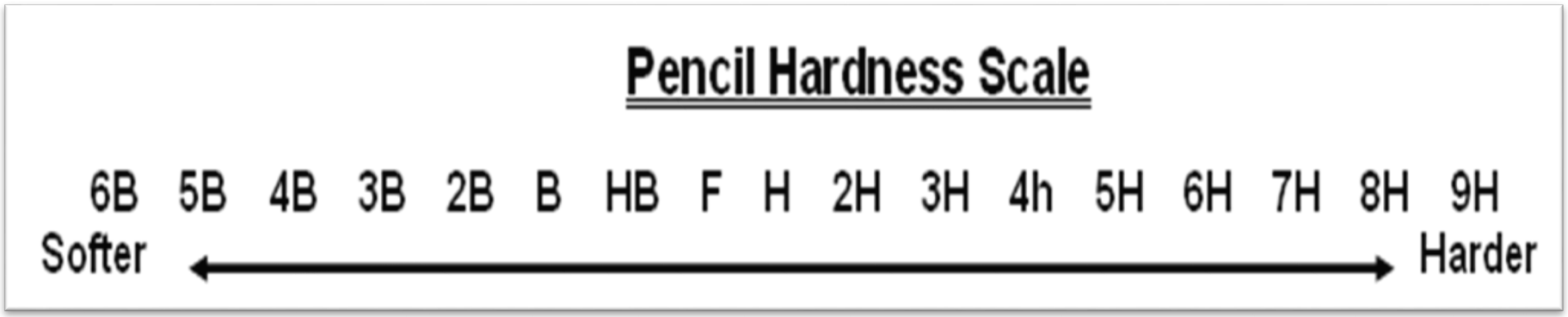
Performance Study

- Objective
  - Compare the scratch resistance of **Nanocomposite Wax 611** *to the same wax without the nanoalumina component*
  - 1% dosage in a water based PUD
    - applied to S-18 aluminum panels (25 µm WFT)
  - Dried for 7 days
- Scratch resistance measured using Taber linear abraser (pencil hardness)

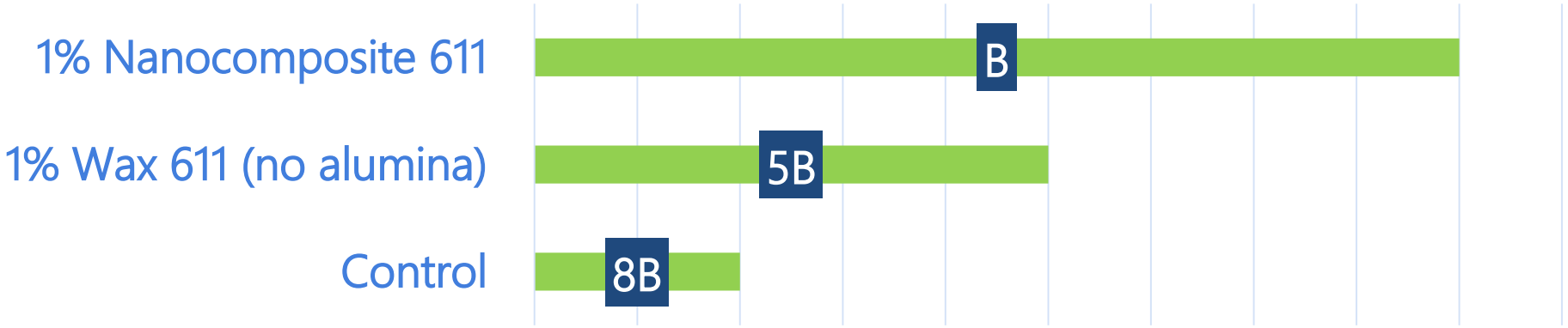
Taber linear abraser



Pencil Hardness Scale



Pencil scratch – Nanocomposite 611



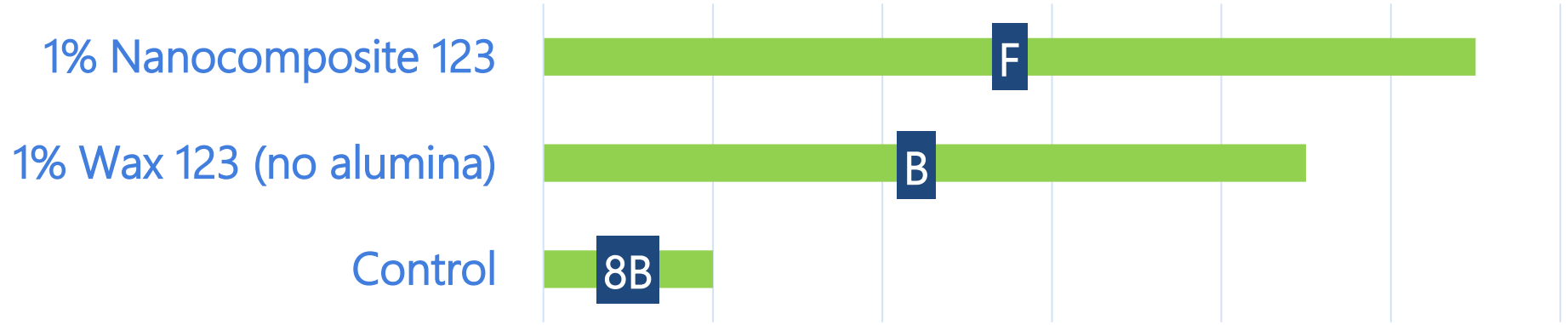
Nanocomposite 611 benefits

- Provides a dramatic improvement in scratch resistance (pencil hardness)
- Easier-to-disperse vs. alumina nanopowders
- Supplied as a safe, non-nano powder
- Suitable for all types of coating systems
- *Composite wax/alumina particle is less abrasive on processing equipment than free alumina*

Nanocomposite Wax 123

- LDPE/alumina nanocomposite
  - Mean particle size 9.5 – 12.5 µm
  - Maximum particle size 31 µm
- Scratch & abrasion for non-slip surfaces
  - Floor coatings and walking surfaces
- Maximum particle toughness
  - LDPE is amorphous and durable

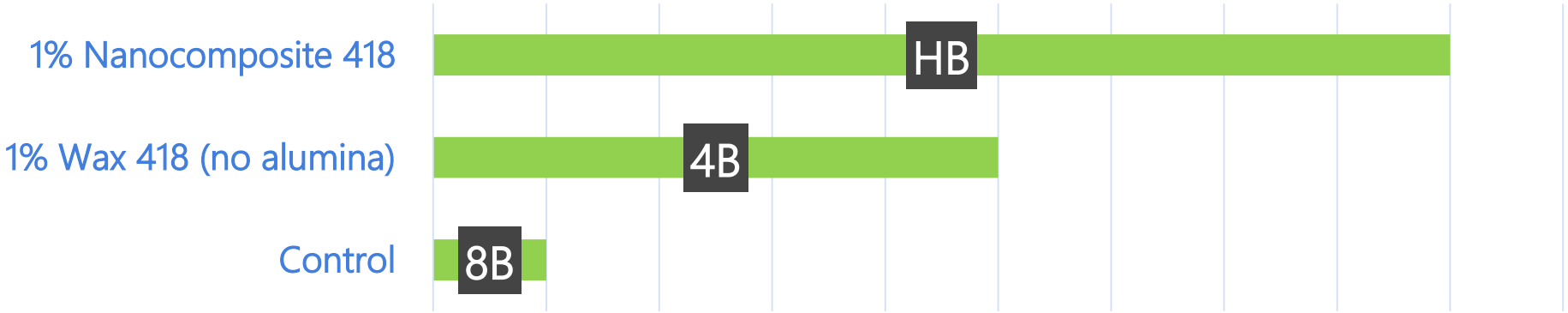
Pencil scratch – Nanocomposite 123



Nanocomposite Wax 418

- Carnauba wax/alumina nanocomposite
  - Mean particle size 6.0 – 8.0 µm
  - Maximum particle size 22 µm
    - Ultrafine particle size ideal for thin film coatings
    - Can and container coatings (175.300 compliant)
    - High biocontent coatings
- Scratch, abrasion, clarity with lubricity and slip
- *Natural and biodegradable wax*

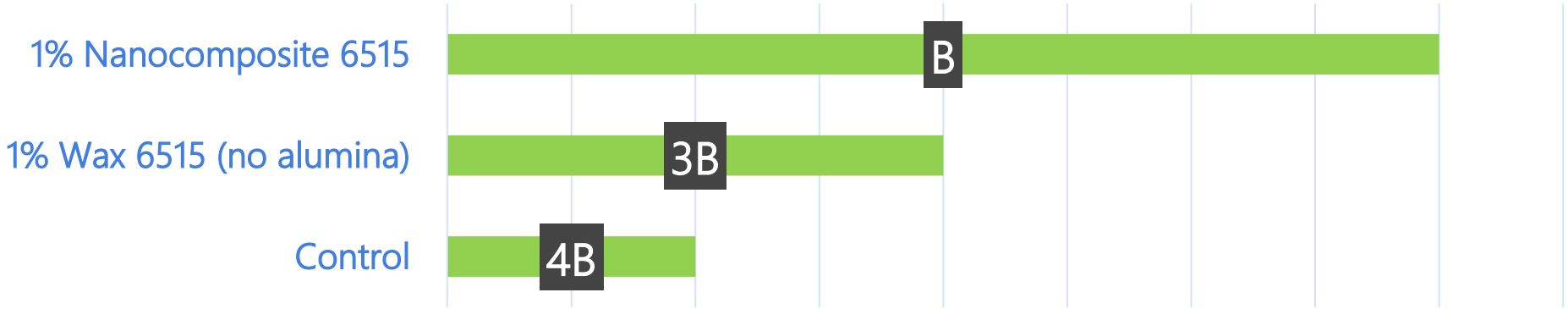
Pencil scratch – Nanocomposite Wax 418



Nanocomposite Wax 6515

- HDPE/amide wax/alumina nanocomposite
  - Mean particle size 3.5 – 5.5 µm
  - Maximum particle size 15.56 µm
    - Ultrafine particle size ideal for thin film coatings
    - Especially useful in wood finishes
- Scratch, abrasion, antiblocking, soft feel (hand)

Pencil scratch – Nanocomposite Wax 6515



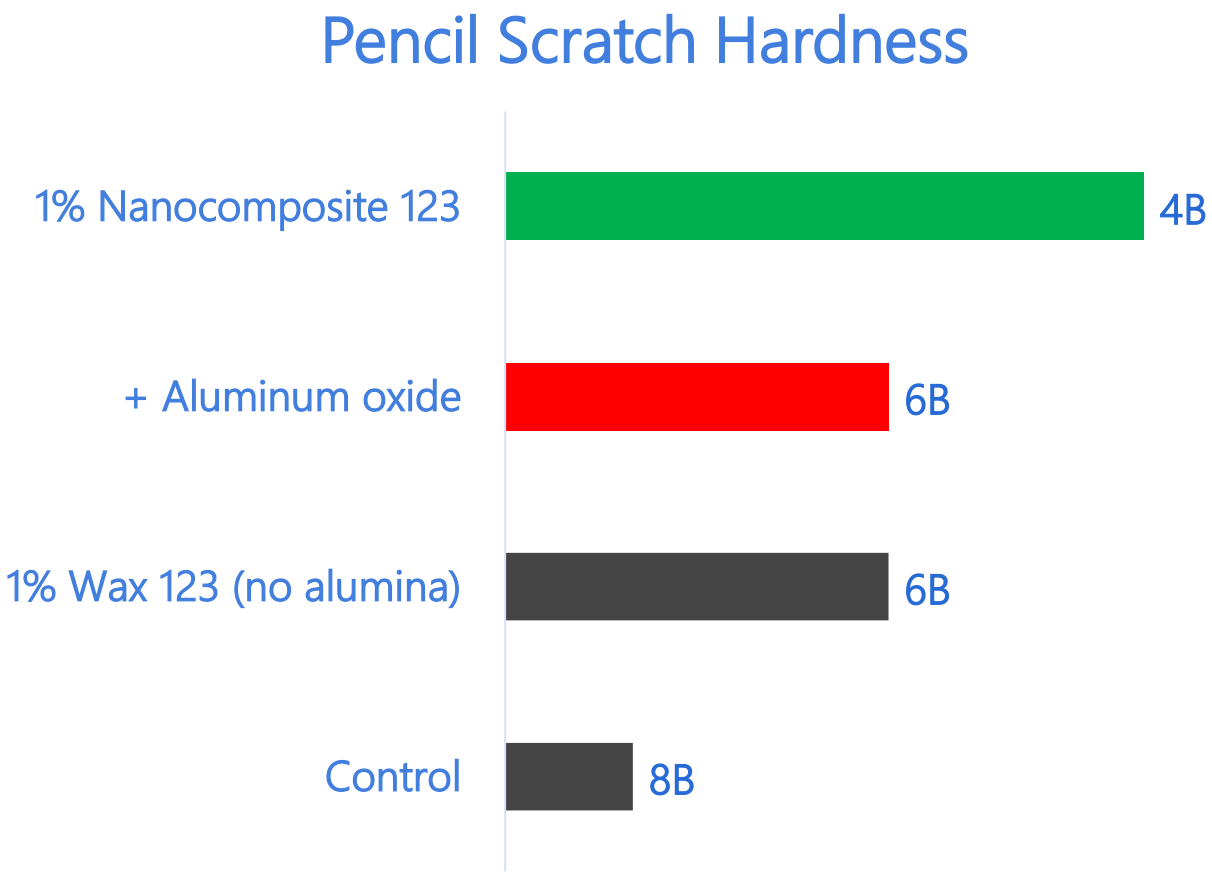
Summary

- In all cases, a wax composite particle containing aluminum oxide showed improved scratch resistance vs. the same wax particle without the alumina modification

Performance vs free alumina

- How do nanoalumina composite waxes compare in performance vs. adding the same dosage of free nanoalumina to the coating?
- Does the buoyancy of the wax matrix help deliver the hard, durable aluminum oxide to the surface?

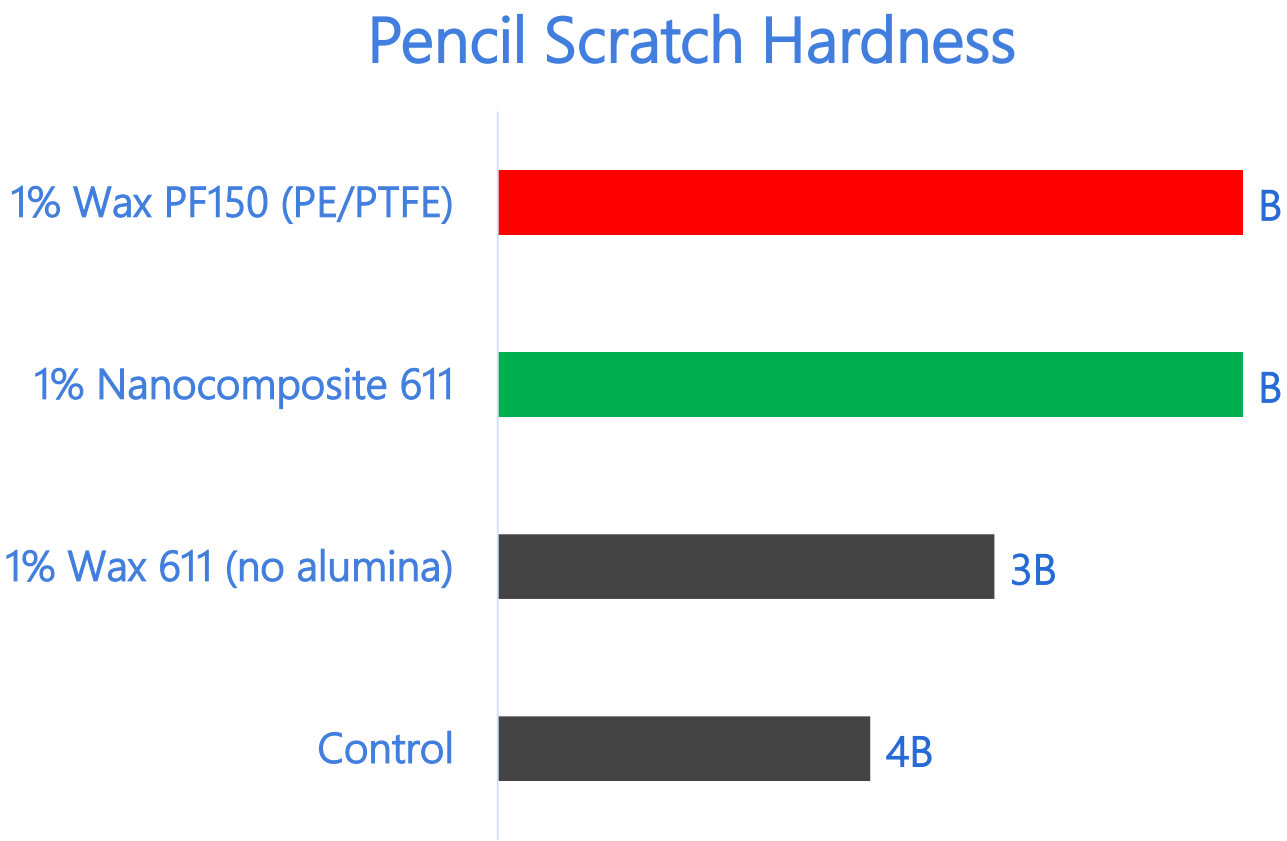
Waterbased PUD formulation



Performance vs PTFE powders

- How do nanoalumina composite waxes compare in performance vs. adding the same dosage of a PTFE wax to the coating?
  - Compare to Wax PF150, a commercial HDPE/PTFE composite wax
- Can a formulator get the same surface durability of a PTFE wax using a nanoalumina wax composite?

Waterbased PUD formulation



Summary & conclusions

- Nanocomposite waxes containing alumina nanopowder can dramatically boost scratch resistance and avoid the issues of dealing with free nanopowder
  - Safety, ease of dispersion, efficiency in use
- Coating formulation costs can be reduced by combining a nanoalumina wax with a cheaper (lower performance) binder

Summary & conclusions

- Nanoalumina wax composites demonstrate improved surface performance compared to the use of free aluminum oxide
- Nanoalumina wax composites can provide identical surface scratch resistance without the use of PTFE

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Questions? Please contact us at:

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