Coatings Trends & Technologies

Nanoalumina Wax Composites for Improved Surface Durability

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High Performance Wax Additives

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Objectives

- Gain an understanding that highly engineered wax additives can actually lower the overall cost of a coating formula
- Explain how composite wax technology will benefit your coatings for scratch resistance and other surface durability properties

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

Choosing the best wax

- It can be complicated!
- What properties are you optimizing?
- Chemistry needs to be considered
  - Water based
  - Solvent based
  - UV/100% solids
- Dry film thickness needs to be understood

What this means to you

- A more efficient wax additive
  - May be more expensive
  - But it gets to the surface more completely
    - Wax that is not at the surface is wasted
  - Often allows the formulator to use a lower dosage vs. a less expensive additive
- *Ideally, use the lowest wax dosage possible to achieve the desired surface effect*

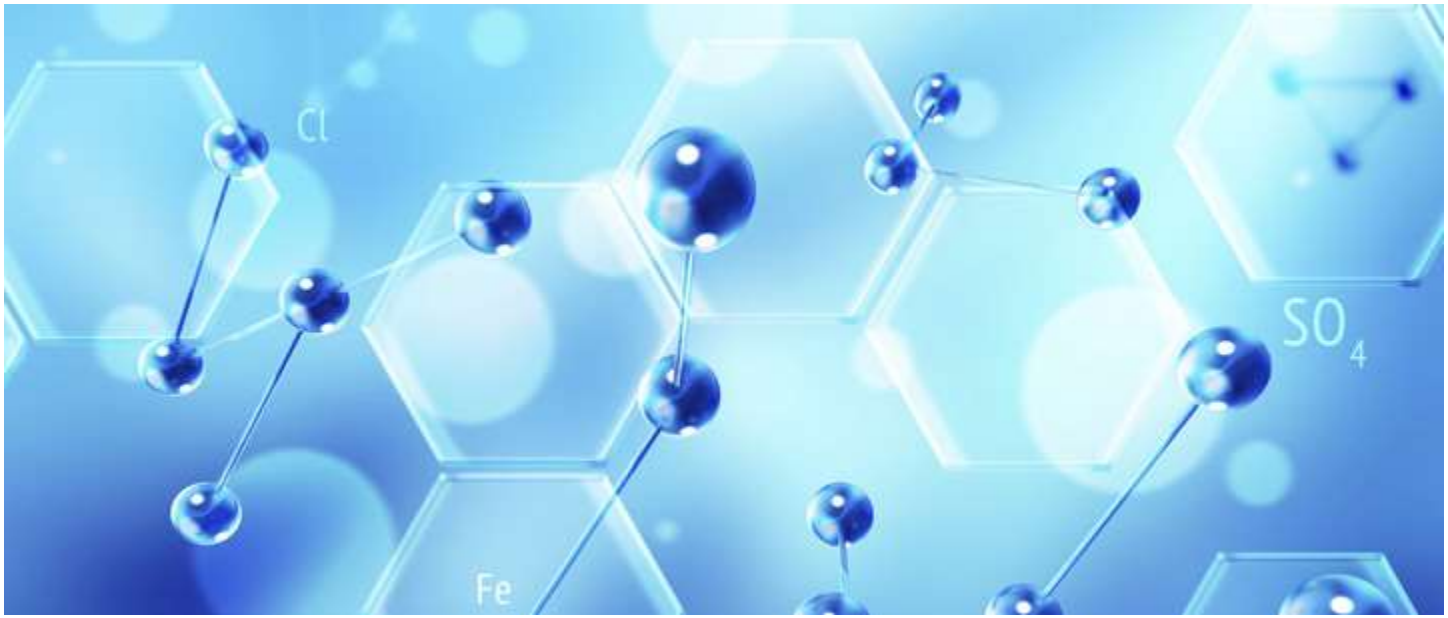
Important properties of wax

- 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?

- A material made from two or more constituent materials . . .
- with significantly different physical or chemical properties . . .
- that, when combined . . .

- *Produce a material with characteristics different from the individual components*

Benefits of composite waxes

Density modification (lighter)

- Heavier waxes will not migrate to a coating surface as efficiently as lighter waxes
  - PTFE vs. polyethylene
- Melt blend polyethylene with microfine PTFE, and then micronizing the composite material
- Composite particle is now less dense than 100% PTFE and therefore more efficient/mobile
  - Change density from 2.2 to 1.07 g/cc

Better efficiency enables a lower wax dosage

Benefits of composite waxes

Density modification (heavier)

- Change the particle density of lighter waxes for improved stability (minimized flotation) in water based and UV systems
- Melt polypropylene with calcium carbonate
- Change density from 0.89 to 1.07 g/cc

A formulated approach to additive design

- Combining 2 or more different materials into one composite wax provides *unique performance benefits not possible with the use of the dry blended wax components*

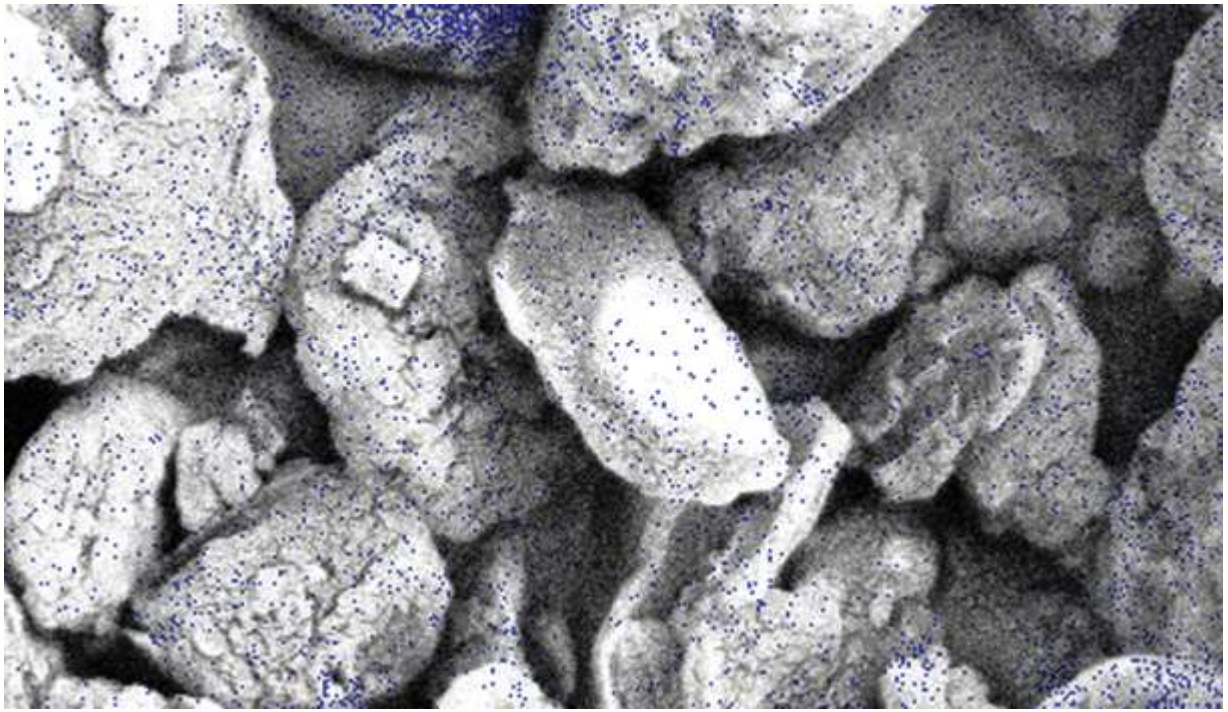
Composite manufacturing process

- Example:
  - Composite wax of polyethylene (PE) and PTFE
- Step 1 – Melt Blending
  - Polyethylene is melted with micronized PTFE
- Step 2 – Cool and Crush
- Step 3 – Micronize
  - Composite material is precisely air micronized to the specified mean/maximum particle size

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

Composites that lower density

- Amorphous LDPE/PTFE
  - Abrasion resistance, anti-blocking, soil release
  - Suitable for floor coatings and other non-skid surfaces
- Crystalline HDPE/PTFE
  - Scratch resistance
  - Slip and lubricity

These lighter wax particles carry the heavier PTFE to the surface more efficiently, allowing lower dosage

Composites that raise density

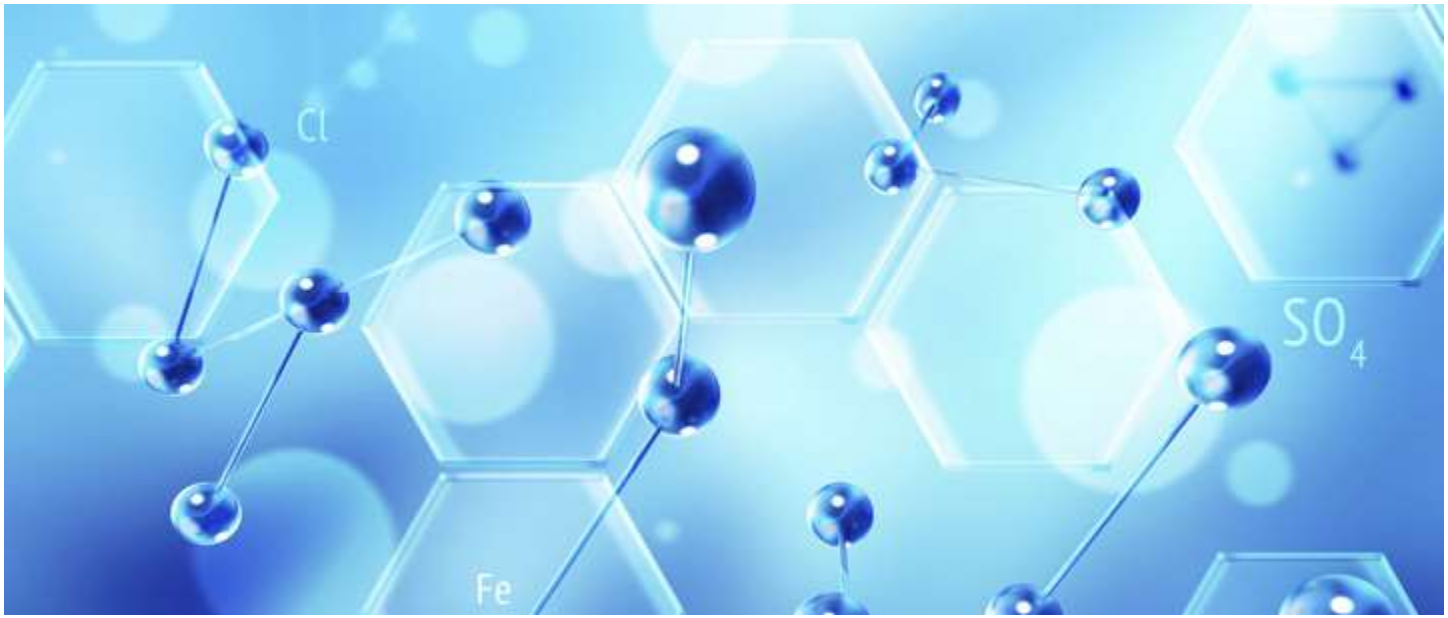
- 10 µm polypropylene densified with calcium carbonate
  - Provides effective gloss reduction with durability, burnish resistance, and a silky feel
- Coarser versions of polypropylene/calcium carbonate
  - Gloss reduction with a range of subtle textures

These heavier (densified) wax particles reduce flotation in waterbased and UV systems

Unique composite products

- LDPE/PTFE/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



Nanotechnology

- Why incorporate a nanomaterial?
  - Materials behave very differently when they are at a nanometer (<100 nm) scale
- In particular, aluminum oxide nanopowders have been used successfully to dramatically improve scratch and abrasion resistance
  - High performance flooring

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

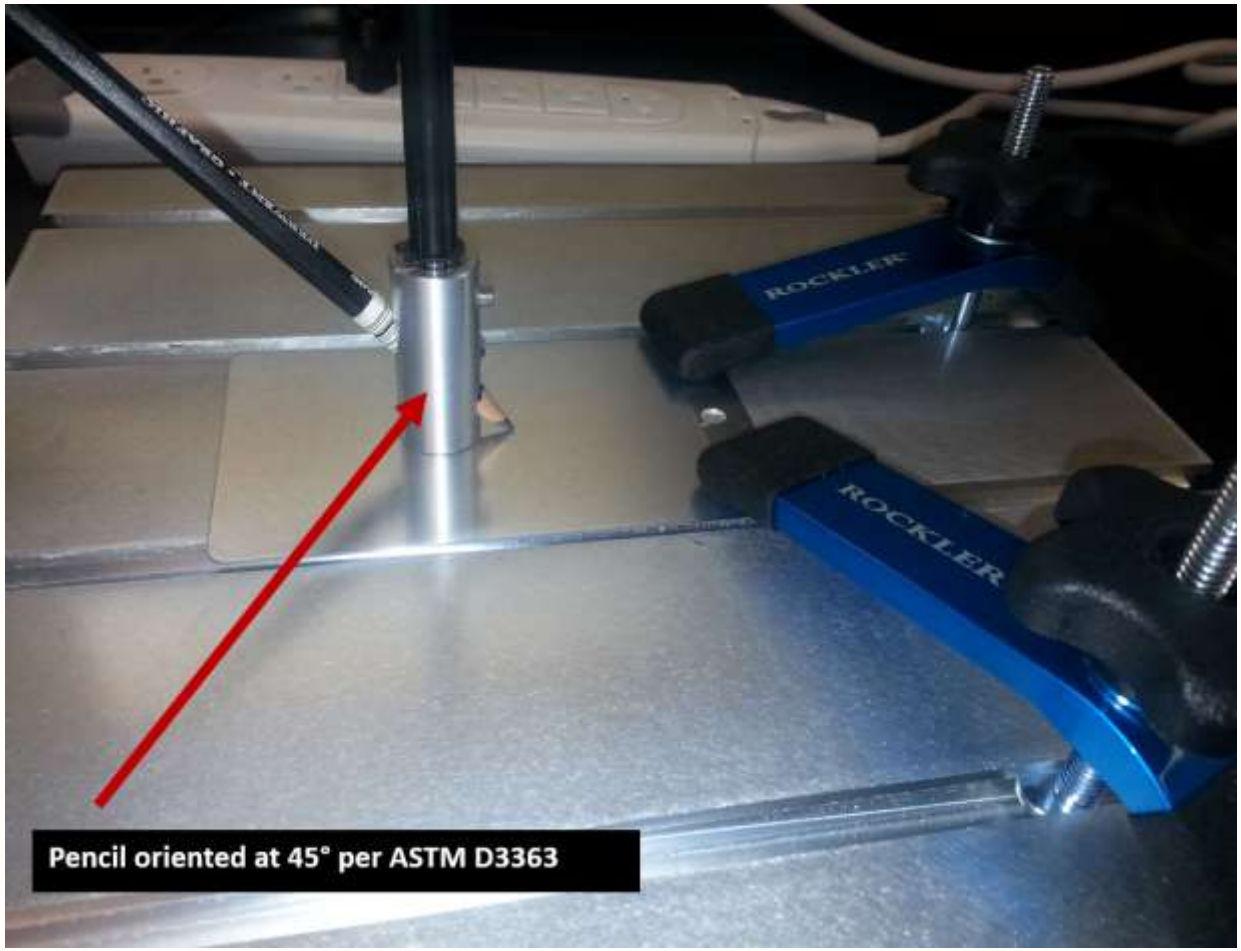
Nanocomposite Wax A

- HDPE/PTFE reinforced with 300 nm aluminum oxide nanoparticles
  - Al_2O_3 has a Mohs Hardness of 9
    - diamond is 10
- Fine particle size
  - Mean particle size 3.5 – 5.5 μm; max. 15.56 μm
- Density of 1.09 g/cc, giving it an excellent combination of in-can stability and mobility

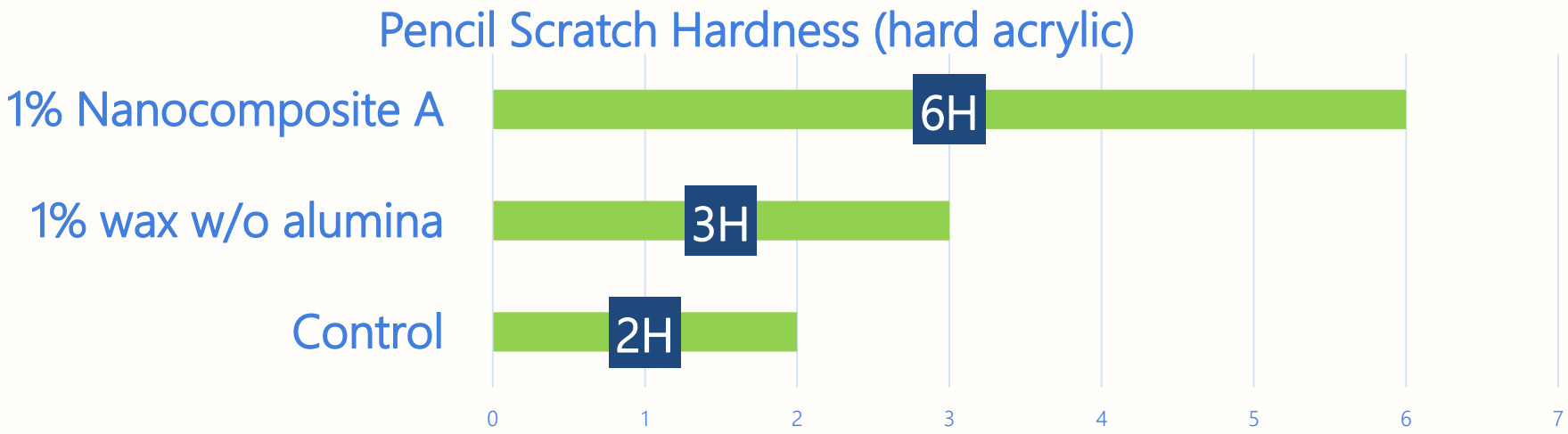
Performance Study

- Objective
  - Compare the scratch resistance of Nanocomposite Wax A to the same wax without the nanoalumina component
  - 1% dosage in a water based acrylic
    - applied to S-18 aluminum panels
  - Tested at 25 & 50 µm WFT
- Scratch resistance measured using Taber linear abraser (pencil hardness)

Taber linear abraser



Pencil scratch – Nanocomposite A



Nanocomposite A 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*

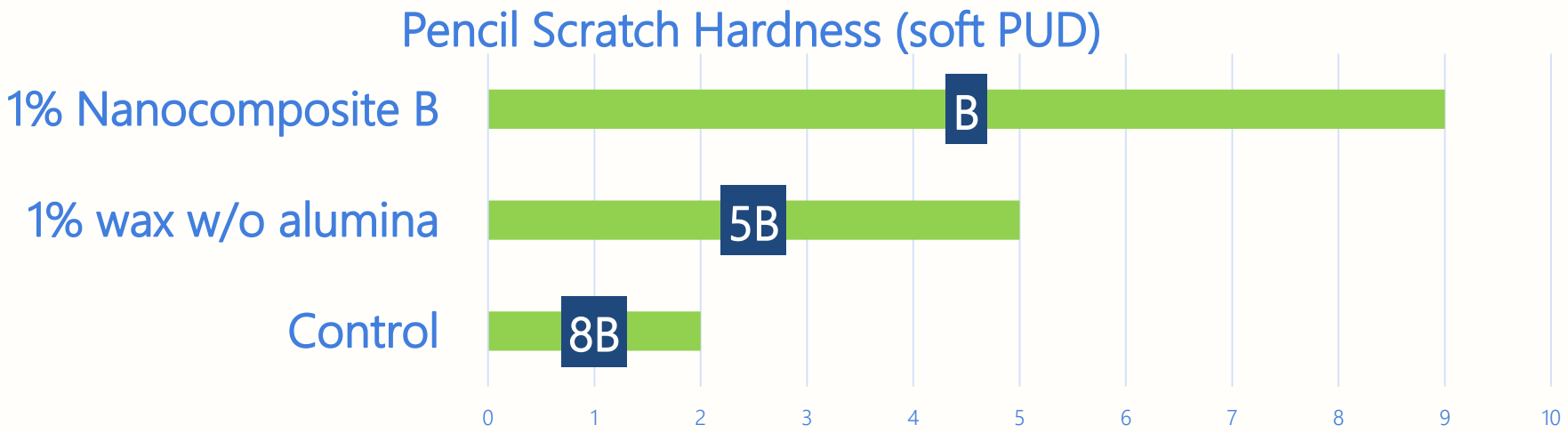
Expanding the benefit

- Nanocomposite Wax A
  - Contains PTFE
  - Is lubricious
  - Is synthetic
- *Can other nanocomposite waxes be developed to suit other types of coatings applications?*
- Yes!

Nanocomposite Wax B

- HDPE/alumina nanocomposite
  - Mean particle size 4.0 – 6.0 µm
  - Maximum particle size 15.56 µm
    - Ultrafine particle size ideal for thin film coatings
- Scratch & abrasion resistance with lubricity and slip
- PTFE free

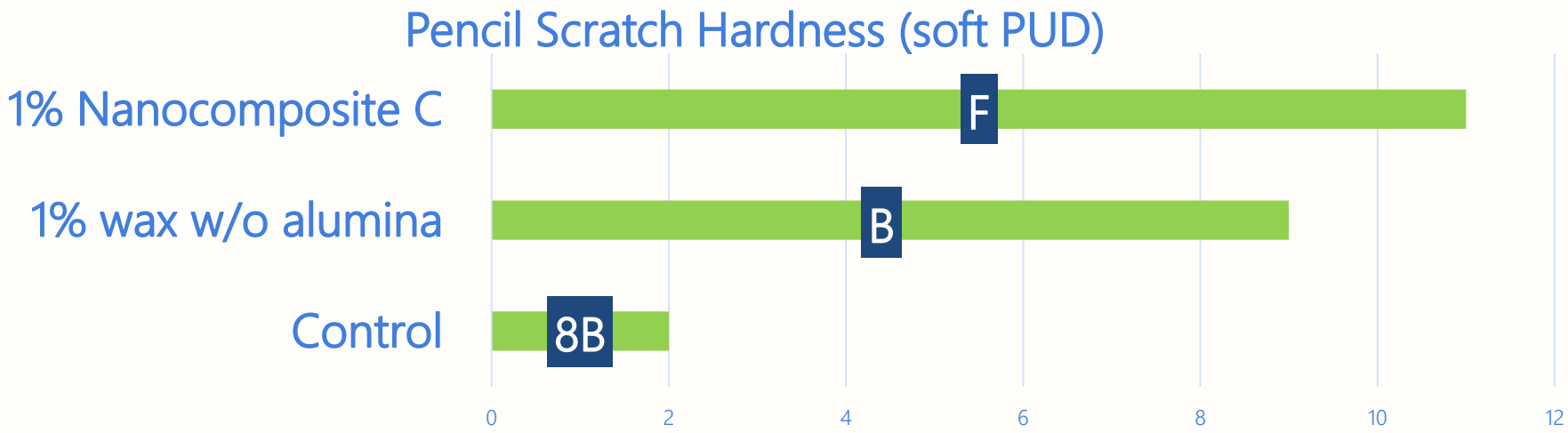
Pencil scratch – Nanocomposite B



Nanocomposite Wax C

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

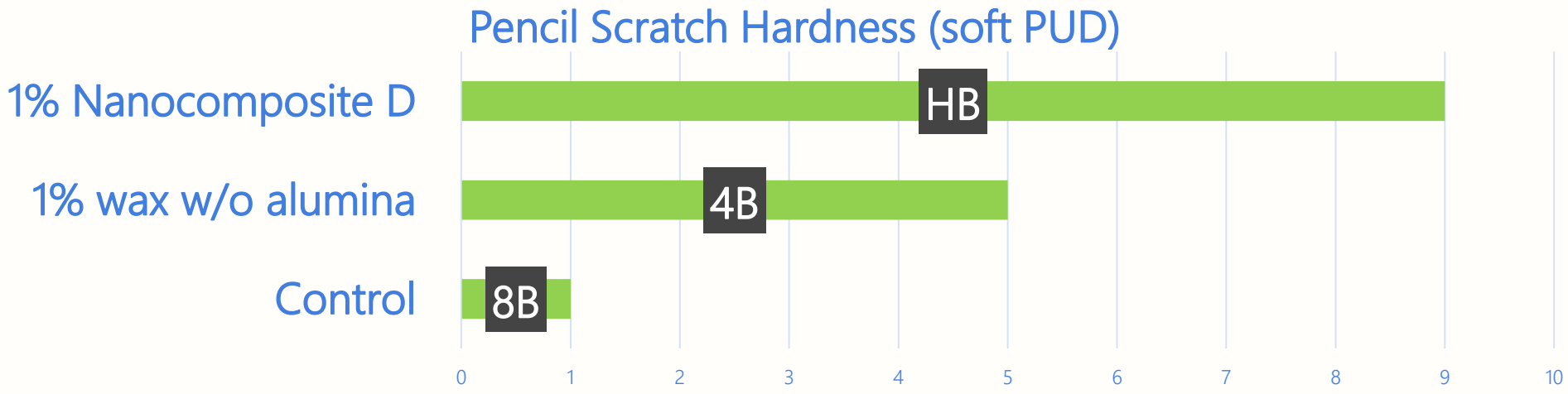
Pencil scratch – Nanocomposite C



Nanocomposite Wax D

- 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
- Scratch, abrasion, clarity with lubricity and slip
- *Natural and biodegradable wax*

Pencil scratch – Nanocomposite Wax D



Summary & conclusions

- Composite wax technology can provide optimum combinations of wax chemistry, particle size, and density (efficiency)
- 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

Summary & conclusions

- Coating systems can be reformulated with softer (lower cost) resin systems and upgraded to achieve surface durability performance of harder (higher cost) grades
- Four different nanoalumina composite additives can be considered depending on the coating type and end use:

Nanocomposite Wax A

- Crystalline HDPE/PTFE/nanoalumina
  - Coatings that require lubricity with maximum scratch resistance
  - Fine particle size for thin film systems including exterior can coatings, coil coatings, plastic coatings
  - Low dosages will have a minimal impact on gloss and film clarity

Nanocomposite Wax B

- Crystalline HDPE/nanoalumina
  - Coatings that require lubricity with maximum scratch resistance without the use of PTFE
  - Fine particle size for thin film systems including
    - Exterior can and container coatings
    - Graphic arts coatings (including energy curables)
    - Wood coatings
  - Low dosages will have a minimal impact on gloss retention

Nanocomposite Wax C

- Amorphous LDPE/nanoalumina
  - Coatings that require maximum scratch and abrasion resistance without lubricity
  - Particle size ideal for gloss reduction
  - Suitable for
    - Industrial floor coatings
    - Burnish resistant coatings
    - Satin and matte coatings

Nanocomposite Wax D

- Natural, biodegradable carnauba wax/ nanoalumina
- Fine particle size minimizes effect on gloss
- Carnauba provides excellent film clarity
- Recommended for
  - High bio-content graphic arts inks & coatings
  - Exterior can and container coatings
  - Seed and agricultural coatings

Questions?
Come see us at Booth #5

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