NanoArc® Aluminum Oxide for Long-Term Scratch and Mar Resistance

Nanophase utilizes a fully-scaled, patent protected plasma based technology to manufacture discrete, fully crystalline nanoscale aluminum oxides. NanoArc® Aluminum Oxide contains no secondary structure, enabling the primary particles to be surface treated with a stability package designed for the particle/liquid interface. This technology platform enables significantly improved transparency and performance.

Benefits of NanoArc® Aluminum Oxide Dispersions

Improving scratch and mar resistance in thin, transparent radiation cured coatings is an ongoing challenge. Aluminum oxide, a well-known additive for improving scratch and mar resistance, is now available in nano and submicron sizes specifically designed for coatings applications. Formulating with NanoArc® Aluminum Oxide dispersions is a cost-effective method for improving a variety of scratch resistant properties that meet the rigorous requirements of clear coatings for wood, laminates, electronics and graphic arts.

NanoArc® Aluminum Oxide dispersions are designed to maintain discrete primary particle stability throughout the coating—a key factor for success.

Benefits include:

• Discrete, non-agglomerated particles in ready-to-use dispersions
• Superior performance for resistance to scuffing, marring, rub-off and other damage to film surface
• Minimal effect on transparency or gloss of coatings
• Improves hardness without loss in mechanical properties of film
• Does not migrate or bloom - No appreciable effect on coefficient of friction - No effect on recoatability
• Effective at low loading levels

Impact of Dispersion Compatibility on Transparency

Compatible Aluminum Oxide in a Clear Coating

Incompatible Aluminum Oxide in a Clear Coating
To meet the increasing demands of scratch and abrasion resistance, NanoArc® Aluminum Oxide is available in a variety of particle sizes. Loading levels of 0.2 to 2.0 wt% aluminum oxide based upon total resin solids provide uncompromising scratch resistance with excellent gloss retention. Performance, clarity, and cost must be taken into consideration when choosing the appropriate NanoArc® Aluminum Oxide. These dispersions have no effect on cure rate or coating viscosity.

Effect of NanoArc® Aluminum Oxide Loading on Pencil Hardness

Aluminum oxide offers scratch and abrasion resistance at much lower loading levels than silica. Aluminum oxide particles are often preferred because of its higher Mohs hardness of 9, compared to 7 for silica. NanoArc® AL-2460 increased the coating hardness from HB up to 3H with 2.0 wt% loading. Aluminum oxide, even at low concentrations, improves scratch resistance, without degrading the appearance of the coating, reducing gloss, or contributing haze.

Effect of NanoArc® Aluminum Oxide Loading on Haze

NanoArc® AL-2460 in 4 mil Thick UV Cured Coating on Glass

Pencil Hardness

% Alumina

Control 20 nm 40 nm 150 nm 250 nm 800 nm

Effect of NanoArc® Aluminum Oxide Loading on Gloss Retention after 50 Cycles with 0000 Steel Wool (0.3 mil thick UV Cured Coating)

Effect of Particle Size on Scratch Resistance

(1 wt% Aluminum Oxide in 0.3 mil thick UV Cured Coating)

Effect of NanoArc® Aluminum Oxide Loading on Gloss Retention after 50 Cycles with 0000 Steel Wool

(0.3 mil thick UV Cured Coating)

Comparison of NanoArc® Aluminum Oxide to Conventional Scratch and Mar Additives

NanoArc® Aluminum Oxide dispersions function differently than conventional slip additives, such as silicones and waxes. NanoArc® Aluminum Oxide does not effect coefficient of friction, gloss or recoatability. Since they do not migrate to the coating interface, they provide long-term scratch and wear resistance. Additionally, they provide superior performance at low loading levels.

Performance Comparison of NanoArc® Aluminum Oxide vs. Conventional Additives After 50 Double Rubs (0000 Steel Wool)

Low Sheen Applications | High Gloss Applications | Transparent Applications
It is important to consider 20 and 40 nm particles for very thin films.

NanoArc® Aluminum Oxide Dispersion Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Particle Size</th>
<th>Fluid</th>
<th>Solids</th>
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<tbody>
<tr>
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<td>Water</td>
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<tr>
<td>AL-2260</td>
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<td>TPGDA</td>
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<td>PM Acetate</td>
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<td>800 nm</td>
<td>TPGDA</td>
<td>55 wt%</td>
</tr>
</tbody>
</table>

Nanophase offers a range of aluminum oxide particle sizes in a variety of dispersion media to ensure compatibility for your project requirements.

Compatibility

NanoArc® Aluminum Oxide dispersions are compatible with a variety of resin systems, including: acrylic, styrene acrylic, polyurethanes, UV curable, epoxies, alkyds, polyesters, and other resin systems.

Recommended Usage Level

NanoArc® Aluminum Oxide Recommended usage levels are 0.20-2.0 wt% alumina solids based upon total resin solids.