Development of Easy-to-Disperse Aluminum Pigments for Waterborne and Solventborne Paint Systems

Jon Lawniczak – ECKART America

2023 Coatings Trends and Technologies Summit
The Westin Lombard, Lombard, IL
September 8, 2023
The Problem

- Use of Aluminum pigments requires pre-dispersion
- Pre-dispersion takes time and pre-dispersion steps may not be routine in the paint making process
- There is a need for an easily dispersible Aluminum pigment
AGENDA

1. The Need for Proper Dispersion of Al
2. Al Passivation Approaches
3. Options for Easy Dispersion
4. Performance Comparisons
Pigment Characteristics
Morphology & Wetting Behavior

Conventional (Corn Flake)  Lenticular (Silver Dollar)

Leafing  Non-leafing
Al Pigment Dispersion and Film Appearance

- Good orientation
- Uniform reflection
- Strong flop, high brilliance, good hiding power

- Poor orientation
- Disordered reflection
- Weak flop, "salt-and-pepper" effect
AI Pigment Dispersion and Film Appearance

Perfect pigment pre-dispersion
Perfect pigment orientation

Aluminium flakes stick together
Aluminium flakes are aggregated
Al Pigment Dispersion and Film Appearance

Dispersing the Al Paste
AI Pigment Dispersion and Film Appearance
AI Pigment Dispersion and Film Appearance
AI Pigment Dispersion Recommendations

1 part aluminium paste

1 - 2 parts solvent
0.5 – 1.0% wetting additives on total formulation

Avoid high shear forces

Usually used solvents: aromatic hydrocarbons, aliphatic hydrocarbons, esters, ketones, alcohols

Usually used wetting agents: Disperbyk 2000, Disperbyk 110, Disperbyk 163

Mixing
AI Pigment Dispersion Recommendations

• Pre-disperse in adequate co-solvent and amount

• Overnight soak is sometimes used

• Solvent : Pigment ratio: 1:1 up to 2:1 (pre-mix)

• Avoid too high shear stress (pre-mix):
  - Pigment deformation leads to loss in brilliancy
  - In water systems, pigment stabilisation can be fractured → Aluminium is exposed to water
AI Pigment Dispersion Recommendations

- Stirring time: approx. 20 – 30 min
- Check on agglomerates after recommended stirring time with a drawdown.
- Keep viscosity mainly constant during completion with formulation elements.
- Make sure the clear binder / solvent / additive mix is free of dirt.
Al Pigment Dispersion Recommendations

proper dispersion  poor dispersion

Slurry poured over glass plate to check degree of dispersion
AI Pigment Dispersion Recommendations
Approach to an Easily Dispersible Al Flake Pigment Starts with Passivation

Additive Technology
• Adsorption of corrosion inhibitors on the active surface of the pigment surface
  • Phosphate esters
  • Molybdate esters

Encapsulation Technology
• Encapsulation of the aluminium pigments with
  • metal oxides
  • silica layer

\[
2\text{ Al} + 6\text{ H}_2\text{O} \rightarrow 2\text{(Al)}\text{OH}_3 + 3\text{H}_2
\]
Al Pigment Passivation Process

1. Aluminum flakes
2. Solvent
3. Water
4. Catalyst

Dryer

Filter press

Passivated Pigments
# Approaches to an Easily Dispersible Al Flake Pigment

<table>
<thead>
<tr>
<th>Choice</th>
<th>Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encapsulated or Passivated</td>
<td>Either</td>
</tr>
<tr>
<td>Paste or Solid</td>
<td>Solid</td>
</tr>
<tr>
<td>Leafing or Non-Leafing</td>
<td>Both</td>
</tr>
<tr>
<td>Compatible with solvents</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Path Forward:**
- Evaluate various dispersing chemistries
- Determine physical form
Approaches to an Easily Dispersible Al Flake Pigment – Passivation Chemistry

- Several combinations of resin and wax provide dispersibility in water.
- We see variations in appearance based on these combinations.
- C is the control leafing pigment.
Approaches to an Easily Dispersible Al Flake Pigment – Physical Form

- 10% pigment to 90% Aquacron 380
- Stir in and Drawdown after
  - 1 min
  - 2 min
  - 5 min
# Physical Form Summary

<table>
<thead>
<tr>
<th>Property</th>
<th>Granular</th>
<th>Pelletized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersibility</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Viscosity</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Foam</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Settling</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Compatibility with Solvents</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Brightness</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Cost</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Ratings: 5 = best; 1 = worst
## Prototype Development

<table>
<thead>
<tr>
<th>Flake Geometry</th>
<th>Type</th>
<th>D50, microns</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornflake</td>
<td>Leafing</td>
<td>20</td>
<td>Granulated Pellet</td>
</tr>
<tr>
<td>Cornflake</td>
<td>Leafing</td>
<td>27</td>
<td>Granulated Pellet</td>
</tr>
<tr>
<td>Cornflake</td>
<td>Non-leafing</td>
<td>9</td>
<td>Granulated Pellet</td>
</tr>
<tr>
<td>Cornflake</td>
<td>Non-leafing</td>
<td>19</td>
<td>Granulated Pellet</td>
</tr>
<tr>
<td>Silver Dollar</td>
<td>Non-leafing</td>
<td>26</td>
<td>Granulated Pellet</td>
</tr>
<tr>
<td>Silver Dollar</td>
<td>Non-leafing</td>
<td>52</td>
<td>Granulated Pellet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilized Aluminum</td>
<td>84 - 89</td>
</tr>
<tr>
<td>Resin</td>
<td>1</td>
</tr>
<tr>
<td>Waxes</td>
<td>10 - 15</td>
</tr>
</tbody>
</table>
Prototype Development
Comparison to WB Paste

Drawdown after 5 min dispersion in clear base

WB Paste Leafing 20 micron CF
Granulated Pellet Leafing 20 micron CF
Prototype Development - Dispersion Ease

HydroSafe

Waterborne Aluminum Paste
Prototype Development - Dispersion Comparison to WB Paste
## Performance Evaluations

### Resin Compatibility

<table>
<thead>
<tr>
<th>WB Resins</th>
<th>Resin Type</th>
<th>Ease of Dispersion</th>
<th>Film</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neocryl A 6016</td>
<td>Acrylic</td>
<td>Fast</td>
<td>Needs coalescing aid (DPM)</td>
</tr>
<tr>
<td>Macrynal SM 6826w/43WA</td>
<td>Acrylic</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>Neocryl A 6075</td>
<td>Styrenated Acrylic</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>NeoRez R 4000</td>
<td>Aliphatic Urethane Hybrid</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>NeoRez R 9029</td>
<td>Aliphatic Urethane Hybrid</td>
<td>Fast</td>
<td>Needs coalescing aid (DPM)</td>
</tr>
<tr>
<td>Daotan TW7010/36WA</td>
<td>Polyurethane Dispersion</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>Resydrol AN 6617w</td>
<td>Polyester</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>Rovace 661</td>
<td>Vinyl Acrylic</td>
<td>Fast</td>
<td>Whitening</td>
</tr>
<tr>
<td>Avicor 325</td>
<td>Vinyl Acetate - Acrylic</td>
<td>Fast</td>
<td>Good</td>
</tr>
<tr>
<td>EpiRez 6520-WH53</td>
<td>Epoxy</td>
<td>Fast</td>
<td>Good</td>
</tr>
</tbody>
</table>
Performance Evaluations

pH Stability

<table>
<thead>
<tr>
<th>Pigment Type</th>
<th>Tested Material, % component</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pigment</td>
<td>Di Water</td>
</tr>
<tr>
<td>19 micron Non-Leafing Cornflake</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>20 micron Leafing Cornflake</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Test Material</td>
<td>33</td>
<td>67</td>
</tr>
</tbody>
</table>

Aging Stability

A 9 micron non-leafing cornflake was aged 3 months at 120F and added to commercial clears

<table>
<thead>
<tr>
<th>Clear</th>
<th>Description</th>
<th>Film Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPG Aquacron 870 LC HV</td>
<td>Acrylic urethane, low gloss</td>
<td>Good</td>
</tr>
<tr>
<td>PPG Aquacron 380 WB</td>
<td>Acrylic paint</td>
<td>Good</td>
</tr>
<tr>
<td>SW Kem Aqua 8710</td>
<td>Acrylic modified alkyd</td>
<td>Good</td>
</tr>
</tbody>
</table>
Performance Evaluations
Humidity Resistance

<table>
<thead>
<tr>
<th>Coating</th>
<th>Wt %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix 5 min to Uniform Dispersion</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>12</td>
</tr>
<tr>
<td>20 Micron leafing Granulated Pellet</td>
<td>8</td>
</tr>
<tr>
<td>Add SW Kem Aqua 8710</td>
<td>80</td>
</tr>
</tbody>
</table>

- Spray applied to steel panels
- DFT ~ 3 mils
- Tested on QUV vs WB paste

168 Hrs

336 Hrs
Performance Evaluations
Solvent solubility

Mineral Spirits
19 micron non-leafing Granule

N-Butyl Acetate

Mineral Spirits
20 micron leafing Granule

N-Butyl Acetate

Washed-out look in MS indicates resin on flake more compatible in polar solvents
Summary
Granulated Pellets

- Dispersion time in water or solvent is approximately 3 - 5 min
- Dispersion time: 10 - 15 min for finished paint systems, depending on wetting properties, viscosity, and batch size
- Draw down on lanetta chart or mylar film to confirm adequate dispersion.
- Draw down should be free of seeds / grit / clumps, etc.
Acknowledgements

- Sean Brown
- Colt Hickerson
- Scott Greer
- Ray Obryan
- Oleg Afanasyev
Thank you for your attention

For More Information Contact Jon Lawniczak
Jonathan.lawniczak@Altana.com
502-365-8033