Fast Dry DTM Alkyd Emulsion with Excellent Corrosion Resistance

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Polynt Composites USA, Inc.
Technical Assistance Manager
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Agenda

- Alkyd Market Overview
- Current Low VOC Alkyd Situation
  - Dry times, 300 Hrs. SS, QCT
- Development of DTM Alkyd Emulsion
  - Dry times, 300 Hrs. SS, QCT
  - Emulsion Physical Properties
  - SPF for a White DTM Gloss Enamel
- Benchmark Studies
  - Dry Times, Hardness, Gloss, 300 Hrs. SS
  - Commercial Waterborne Alkyds
  - Solventborne Alkyds
- Conclusion
U.S. Alkyd Market

- 858.8 MM pounds worth $2.41 billion in 2011
  - Forecast to decline 2% per year through 2016
- Projected 781.3 MM pounds worth $2.27 billion in 2016
- Waterborne alkyd consumption has been growing, but only 49.1 MM pounds worth $203.1 MM in 2011
  - Forecast to grow ~ 3% per year through 2016
- Projected 55.5 MM pounds worth $230.7 MM in 2016

- Faster growth possible if performance equal to solvent-borne alkyds

Kusumgar, Nerfi & Growney, The U.S. Paint & Coatings Industry, 2011-16
Background

- Solvent-borne Alkyds – High Gloss, Good Adhesion, and Great Versatility

- Solvent-borne Alkyds Continue to Dominate the Alkyds Market
  - Industrial applications require excellent metal protection
  - Current low VOC options, such as waterborne alkyds, have performance gaps:
    - Gloss
    - Corrosion resistance
    - Hardness development
Environmental Trends to Lower VOC

- Environmental Trends Are Driving Growth in Waterborne Alkyds
- Many resin companies have multiple products in the marketplace
  - These products have shortcomings
- We interviewed our customers who use waterborne alkyds
  - Dry fast, but poor corrosion
  - Good corrosion, but dry too slow
  - Based on these interviews, we set our objectives for this development
Current Low VOC Alkyd Systems

- High Solids Alkyds
  - Increased solids = lower MW, for lower viscosity
    - Increase dry times
    - Reduce performances – Salt Spray, Chemicals, Humidity, etc.

- Water Reducible Alkyds
  - Incorporate excess acid functionality
  - Neutralize with amine to disperse in water
  - Supplied in hydrophilic solvent at 70-75% NV
  - VOC still relatively high – 300-380 g/L VOC
  - Short paint shelf life due to hydrolysis ~ 6 months
    - Lower VOC blend, high Tg latex
Current Low VOC Alkyd Systems

- **Alkyd Emulsions**
  - Emulsification with anionic/nonionic surfactants
  - Water in Oil to Oil to Water inversion
  - Surfactant shell protects from hydrolysis
  - Typically high shear process needed
  - Low VOC
  - (-) Can require high levels of surfactants (5-10%)
  - (-) Reduced corrosion resistance
  - (-) Reduced water resistance
## Competitive Alkyd Emulsions

<table>
<thead>
<tr>
<th>2 mils wet circular dry chart</th>
<th>Set to Touch</th>
<th>Tack-free</th>
<th>Print-free</th>
<th>Through Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitor #1</td>
<td>30 min.</td>
<td>1 hr., 50 min.</td>
<td>3 hrs., 15 min.</td>
<td>9 hrs., 10 min.</td>
</tr>
</tbody>
</table>

300 hrs. SS

16 hrs. QCT
## Competitive Alkyd Emulsions

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</tr>
</thead>
<tbody>
<tr>
<td>Competitor #2</td>
<td>30 min.</td>
<td>2 hrs., 50 min.</td>
<td>4 hrs., 15 min.</td>
<td>9 hrs., 10 min.</td>
</tr>
</tbody>
</table>

| 300 hrs. SS                  | 16 hrs. QCT  |

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*Images show the results of testing Competitor #2 with 300 hours of SS (Salt Spray) and 16 hours of QCT (Quartz Counter-Tack).*
Current Low VOC Alkyd Systems

- Modified Alkyd Dispersions
  - High Tg acrylic shell, soft alkyd core
  - Protects from hydrolysis
  - Neutralized with amine for water dispersibility
  - Harder films, faster dry
  - (-) Poor corrosion protection
  - (-) Increased hydrophilicity of alkyd segment
# Competitive Core Shell Acrylic Modified

<table>
<thead>
<tr>
<th>Competitive – 2 mils wet circular chart</th>
<th>Set to Touch</th>
<th>Tack-free</th>
<th>Print-free</th>
<th>Through Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitor #3</td>
<td>30 min.</td>
<td>40 min.</td>
<td>55 min.</td>
<td>3 hours</td>
</tr>
<tr>
<td>Competitor #4</td>
<td>5.5 min.</td>
<td>10.2 min.</td>
<td>21 min.</td>
<td>34.1 min.</td>
</tr>
</tbody>
</table>

300 hrs. SS
Current Waterborne Alkyds Fall Short

- Fast dry, but poor corrosion
- Good corrosion, but poor water resistance and slower dry
- Paint companies use alkyd emulsions/dispersions because need near zero VOC
  - Not because of performance

- Our goal:
  - Bridge the Performance Gap
  - Leapfrog over existing waterborne alkyds technologies
DTM Alkyd Emulsion Deliverables

- Good hardness development
  - Past POLYNT development – were too soft
- 300 hrs. salt spray @ 1.5 – 2.0 mils DFT
  - 90 hrs. salt spray @ 1.25 mils DFT – clear
- Dry to touch < 1 hour
- Tack-free < 6 hours
- Through dry < 12 hours
- High gloss – 80+ at 60°
Technical Approach

- Modify alkyd to perform in water
  - Previous approach – emulsify existing alkyds
  - Not same performance as solvent-borne alkyd
    - Slower cure – 50% hardness development
    - Thus, 50% film performance

- Reconstruct alkyd backbone
  - Improved alkyd emulsion stability
  - Improved hardness development
  - Improved corrosion protection
Developmental Waterborne Alkyd Emulsions

- **Typical Physical Properties**
  - Appearance – milky white liquid
  - WNV – 50-60%
  - Particle Size (nm) – 200-500 nm
  - Viscosity (cP) – Prototype #1 – 6000-8000
    Prototype #2 – 450-650
  - pH – 5.5 – 6.5
## WB Alkyd White Paint Formulation

<table>
<thead>
<tr>
<th>Component</th>
<th>Pounds</th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>57.45</td>
<td>6.89</td>
</tr>
<tr>
<td>Dispersant</td>
<td>4.92</td>
<td>0.56</td>
</tr>
<tr>
<td>Defoamer</td>
<td>1.45</td>
<td>0.29</td>
</tr>
<tr>
<td>TiO2</td>
<td>216.41</td>
<td>6.49</td>
</tr>
<tr>
<td>prototype 1/2</td>
<td>491.85</td>
<td>53.58</td>
</tr>
<tr>
<td>Surfactant</td>
<td>1.95</td>
<td>0.22</td>
</tr>
<tr>
<td>Surfactant</td>
<td>0.98</td>
<td>0.11</td>
</tr>
<tr>
<td>Defoamer</td>
<td>4.06</td>
<td>0.46</td>
</tr>
<tr>
<td>Drier Package</td>
<td>3.08</td>
<td>0.34</td>
</tr>
<tr>
<td>Drier Activator</td>
<td>3.08</td>
<td>0.39</td>
</tr>
<tr>
<td>Flash Rust inhibitor</td>
<td>10.28</td>
<td>1.12</td>
</tr>
<tr>
<td>Rheology</td>
<td>3.08</td>
<td>0.36</td>
</tr>
<tr>
<td>Water</td>
<td>243.47</td>
<td>29.19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1042.06</strong></td>
<td><strong>100.00</strong></td>
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</table>
## New Polynt Short CS Alkyd Emulsion

<table>
<thead>
<tr>
<th>2 mils wet circular chart</th>
<th>Set to Touch</th>
<th>Tack-free</th>
<th>Print-free</th>
<th>Through Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototype #1</td>
<td>60min.</td>
<td>2.75 hrs.</td>
<td>3.25 hrs.</td>
<td>6.5 hrs.</td>
</tr>
<tr>
<td>Prototype #2</td>
<td>30 min.</td>
<td>1.5 hrs.</td>
<td>3.0 hrs.</td>
<td>5.0 hrs.</td>
</tr>
</tbody>
</table>

300 hrs. SS

16 hrs. QCT
Benchmark Studies

- Two Polynt commercial solvent-borne alkyds
- Polynt water reducible alkyd
- Four commercial alkyd emulsions/dispersions
- Commercial alkyd emulsion paint
- Two prototype Polynt alkyd emulsions
## Comparison to Commercial WB Resins

<table>
<thead>
<tr>
<th>Sample</th>
<th>Proto-type #1</th>
<th>Proto-type #2</th>
<th>Polynt Water Reducible</th>
<th>Comm. WB Alkyd #1</th>
<th>Comm. WB Alkyd #2</th>
<th>Comm. WB Alkyd #3</th>
<th>Comm. WB Alkyd #4</th>
<th>Comm. WB Alkyd Paint</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC (g/L)</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>320</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>DFT (mils)</td>
<td>1.09</td>
<td>1.01</td>
<td>0.96</td>
<td>1.04</td>
<td>1.00</td>
<td>0.96</td>
<td>0.99</td>
<td>0.94</td>
</tr>
<tr>
<td>Tack-free (hrs.)</td>
<td>2.75</td>
<td>1.5</td>
<td>1.5</td>
<td>1.8</td>
<td>2.8</td>
<td>0.67</td>
<td>0.17</td>
<td>0.18</td>
</tr>
<tr>
<td>Through Dry (hrs.)</td>
<td>6.5</td>
<td>5</td>
<td>12</td>
<td>9.0</td>
<td>9.0</td>
<td>3.0</td>
<td>0.58</td>
<td>0.92</td>
</tr>
<tr>
<td>60° Gloss</td>
<td>90</td>
<td>86</td>
<td>97</td>
<td>93</td>
<td>67</td>
<td>75</td>
<td>76</td>
<td>68</td>
</tr>
<tr>
<td>Konig Hardness</td>
<td>41</td>
<td>41</td>
<td>88</td>
<td>36</td>
<td>29</td>
<td>60</td>
<td>58</td>
<td>46</td>
</tr>
</tbody>
</table>
300 hrs. SS vs. Commercial WB Alkyd Paint

Prototype #1

Prototype #2

Commercial WB Alkyd Paint
300 hrs. SS vs. Polynt Water Reducible Alkyd

Prototype #1  Prototype #2  Commercial Polynt WR Alkyd
300 hrs. SS vs. Commercial Alkyd Emulsions
300 hrs. SS vs. Commercial Core Shell WB Alkyds

Prototype #1
Prototype #2
Competitive WB Core Shell Alkyd #3
Competitive WB Core Shell Alkyd #4
Comparison to Commercial SB Resins

<table>
<thead>
<tr>
<th>Sample</th>
<th>Prototype #1</th>
<th>Prototype #2</th>
<th>Polynt SB #1</th>
<th>Polynt SB #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC (g/L)</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>560</td>
<td>480</td>
</tr>
<tr>
<td>DFT (mils)</td>
<td>1.09</td>
<td>1.01</td>
<td>1.35</td>
<td>0.96</td>
</tr>
<tr>
<td>Tack-free (hrs.)</td>
<td>2.75</td>
<td>1.5</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Through Dry (hrs.)</td>
<td>6.5</td>
<td>5</td>
<td>0.83</td>
<td>6.67</td>
</tr>
<tr>
<td>60° Gloss</td>
<td>90</td>
<td>86</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Konig Hardness</td>
<td>41</td>
<td>41</td>
<td>87</td>
<td>82</td>
</tr>
</tbody>
</table>
300 hrs. SS vs. Solvent-borne Alkyds

Prototype #1  Prototype #2  Polynet SB Alkyd #1  Polynet SB Alkyd #2
Summary

- Two prototypes developed
- Outstanding corrosion protection
  - Better than most commercial alkyd emulsions out there
  - Better than solvent-borne alkyds
  - Slight improvements versus water reducible alkyds at much lower VOC
- Outstanding water resistance
- Fast tack-free and through dry
- High Gloss
- Limited sampling in next 60 days
Acknowledgements

- Harrison Schuster
- Robert Murphy
- Jim Prom – Synthesis Consultant
300 hrs. SS at 1.0-1.5 mils