Developments in Fluoropolymer Resins For Long Life Coatings

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Winn Darden
Business Manager, LUMIFLON® Resins
AGC Chemicals Americas
Exton, PA
wdarden@agcchem.com
Fluoropolymers in Coatings

• Characteristics of Fluoropolymers
  – Excellent weatherability
  – Good chemical resistance
  – Low surface energy
  – Poor solubility
  – Difficult to apply

• PVDF Coatings
  – Coil coating

• Market Needs
  – Ambient cure
  – Easy to apply
  – Physical properties close to familiar coatings
Fluoroethylene Vinyl Ether (FEVE) Resins

**Fluoro Ethylene**

**Vinyl Ether**

**FLUORINATED SEGMENTS:** Weatherability, durability, chemical resistance

**VINYL ETHER SEGMENTS:** Gloss, solubility, crosslinking
Advantages of FEVE Based Coatings

• Ambient Cure
  – Field applied coatings

• OH Functional
  – Fluorourethanes

• Solvent Soluble
  – Clean, crisp colors
  – Wide range of gloss

• Fluoropolymer Segments
  – Ultra-weatherable
  – Corrosion resistance
Weathering of FEVE Coatings
QUV-A Test (ASTM D4587)

Gloss Retention, %

Hours

Fluorourethane
Polysiloxane
Acrylic Urethane

AGC
Weathering of FEVE Resin Topcoats
South Florida Weathering

Florida exposure test on LF-200
## Comparative Weathering of Fluorourethane Topcoat

<table>
<thead>
<tr>
<th>Test Site</th>
<th>Test Duration</th>
<th>Topcoat Type</th>
<th>Initial μm</th>
<th>Final μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suruga Bay</td>
<td>16 years</td>
<td>Acrylic Urethane</td>
<td>25</td>
<td>0 (13 yrs.)</td>
</tr>
<tr>
<td>Suruga Bay</td>
<td>16 years</td>
<td>Fluoro-Urethane</td>
<td>25</td>
<td>21</td>
</tr>
</tbody>
</table>
Prevention of Corrosion with FEVE Resin Topcoats

Electrochemical Impedance Spectroscopy

- Coating System Tested
  - Zinc rich primer/epoxy/topcoat
- Shows Effectiveness of Topcoat in Preventing Corrosion
- Accelerated Weathering Followed by Salt Fog Test
- Smaller Change, Better Corrosion Resistance
Types of FEVE Resins

• Solvent-Based
  – Dissolved in xylene
  – Difficult to meet VOC/HAPS regulations

• Develop New Resin Forms For New Standards

• Solid Resins
  – Powder coatings

• Water Emulsions

• New Water-Based Resin
FEVE Solid Resins

• Same Performance as Solvent Based Resins
  – Weatherability
  – Corrosion resistance

• Soluble in Exempt Solvents
  – Oxsol 100
  – T-butyl acetate
  – Acetone

• Soluble in: Propylene Glycol
  Ethers, Esters, Ketones

• Meet 100 g/l California Standard for Industrial
  Maintenance Coatings
FEVE Water Emulsions

- Modified structure for emulsion stability
- High molecular weight
- Film forming via coalescence
- Affects film properties
  - Water resistance
  - Weathering
  - Adhesion
  - Permeability
- Problems at 50 g/l VOC?
FEVE Water Emulsions

- Used in Blends With Standard Resins
  - Improved weatherability
  - Improve gloss and color retention

Blend of Single Component FEVE Water Emulsion with Primal® PR-1042 (Rohm & Haas)
FEVE Water Based Resins

• Need for Water-Based Resin With Properties Matching Solvent-Based Resins
  – Water resistance
  – Weatherability

• Minimize Changes to FEVE Polymer
  – Less modification, better properties

• FEVE Water Dispersion
FEVE Water Dispersions
Producing Dispersions

Solid FEVE resin → Acid modification → Neutralized by amine → Water added & Solvent volatilized

OH → OC~COOH → OC~COOHNR3 → OC~COONR3

In solvent → In water
# FEVE Water Dispersions
## Typical Physical Properties

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Milky White Liquid</td>
</tr>
<tr>
<td>Solids, wt. %</td>
<td>40%</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
</tr>
<tr>
<td>Particle Diameter, µm</td>
<td>145</td>
</tr>
<tr>
<td>Minimum Film Forming Temperature, °C</td>
<td>27</td>
</tr>
<tr>
<td>Acid Value, mg KOH/g-polymer</td>
<td>15</td>
</tr>
<tr>
<td>Hydroxyl Value, mg KOH/g-polymer</td>
<td>85</td>
</tr>
</tbody>
</table>
## Properties of FEVE Dispersion Coatings

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>FEVE Dispersion, 2K</th>
<th>FEVE Emulsion, 2K</th>
<th>FEVE Solvent, 2K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloss, 60°</td>
<td>ISO 2813</td>
<td>88</td>
<td>78</td>
<td>90</td>
</tr>
<tr>
<td>Pencil Hardness</td>
<td>ASTM D 3363</td>
<td>Gouge</td>
<td>4H</td>
<td>4H</td>
</tr>
<tr>
<td>Pendulum Hardness</td>
<td>ASTM D 4366</td>
<td>79</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>ASTM D 2794</td>
<td>Intrusion 0.5 kg</td>
<td>&gt;1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Diameter=0.5”</td>
<td>Extrusion 0.5 kg</td>
<td>&gt;1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Cross Cut Adhesion</td>
<td>ASTM D 3359</td>
<td>5B</td>
<td>5B</td>
<td>5B</td>
</tr>
<tr>
<td>Water Resistance</td>
<td>ISO 2812, 40 C, 24 h Cross Cut Adhesion Blistering</td>
<td>4B</td>
<td>No blistering</td>
<td>Medium blisters</td>
</tr>
</tbody>
</table>
Comparative Weathering of FEVE Water Dispersions (QUV-B)
SEM: FEVE Dispersion vs. Emulsion
Markets for Fluorourethane Coatings

- **Architectural Markets**
  - Monumental buildings
  - Aluminum extrusions
  - Coil coatings

- **Aerospace Coatings**
  - Military: C-17, C-5
  - Commercial and general aviation

- **Industrial Maintenance Coatings**
  - Difficult to paint structures: bridges, water towers

- **Automotive**

- **Specialty Markets**
  - Solar panels
  - Wind towers
Applications for FEVE Coatings
Applications for FEVE Coatings
Applications for FEVE Coatings
Conclusions

• Fluorourethanes Impart
  • Fluoropolymer characteristics
  • Excellent weatherability
  • Corrosion resistance

• FEVE Resins in Use for More Than 25 Years
  • Required for bridge topcoats in Japan
  • Estimated life of 60 years
  • Lower life cycle costs

• New Resins Meet Changing Environmental Regulations

• FEVE Coating Life Matches Infrastructure Life