“FEVE Fluoropolymer Emulsions for Performance Improvement in Architectural Coatings”

Bob Parker
29th Western Coatings Symposium
FEVE Fluoropolymer Resins

- "FEVE" is abbreviation for "Fluoroethylene Vinyl Ether" resins for coatings

- Known for their high performance properties:
  1) Exceptional resistance to UV degradation
  2) Superior Chemical Resistance
  3) Excellent Thermal Resistance

- Known for their unique formulation properties:
  1) Solvent soluble
  2) Can be cured at ambient temperature with isocyanates
  3) Can achieve high gloss formulations
Fluoroethylene Vinyl Ether (FEVE) Resins

**Fluoro Ethylene**

**Vinyl Ether**

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

**VINYL ETHER SEGMENTS:** Gloss, solubility, crosslinking
Commercial Types of "FEVE" Resins:

1) *Solvent soluble resins* –
   uses organic solvents for viscosity reduction;
   predominantly cured with isocyanates; available as
   resin solutions or as 100% solid resins

2) *Water-based emulsions* –
   use vinyl ether macromonomers containing
   polyoxyethylene (EO) units to create stable emulsions
# FEVE Emulsions in Architectural Coatings

## FEVE Water-borne Emulsions

<table>
<thead>
<tr>
<th></th>
<th>FE-4300</th>
<th>FE-4500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solids (Wt.)</strong></td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>7 to 9</td>
<td>7 to 9</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>1.13</td>
<td>1.17</td>
</tr>
<tr>
<td><strong>MFT</strong></td>
<td>35°C.</td>
<td>28°C.</td>
</tr>
<tr>
<td><strong>Hydroxyl Value</strong></td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>
## White House Paint Formulation Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids (Volume)</td>
<td>32%</td>
</tr>
<tr>
<td>pH</td>
<td>9.0 to 9.5</td>
</tr>
<tr>
<td>TiO₂ Choice</td>
<td>TiPure R-706</td>
</tr>
<tr>
<td>PVC</td>
<td>22</td>
</tr>
<tr>
<td>Thickeners</td>
<td>both cellulosic and associative</td>
</tr>
<tr>
<td>60° Gloss Range</td>
<td>50-65</td>
</tr>
<tr>
<td>VOC</td>
<td>1.24#/gal. or 150 g/liter</td>
</tr>
</tbody>
</table>
Testing procedure # 1:

1) Blending of FEVE emulsions and 4 different acrylic emulsions to evaluate stability (3 weeks in 140°F. oven)

2) Manufacture of 3 White House Paint formulations for each acrylic emulsion:
   a. Binder = 100% Acrylic Emulsion
   b. Binder = 50% Acrylic Emulsion + 50% FE-4300 (FEVE Emulsion)
   c. Binder = 50% Acrylic Emulsion + 50% FE-4500 (FEVE Emulsion)

3) Stability testing of all formulations (6 weeks in 120°F. oven)

4) Preparation of test panels (primed Al panels coated with 4 wet mils of coating)

5) QUV Weatherometer Exposure (UVA 340 Bulbs used)
   a. Test Cycle = 8 hours UV light @ 60°C. + 4 hours condensation @ 50°C.
Gloss Decrease - Acrylic #1 and 50/50 Blends

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500

60° Gloss Decrease (%)

Hours in QUV Weatherometer
Gloss Decrease - Acrylic #2 and 50/50 Blends

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500
Gloss Decrease - Acrylic #3 and 50/50 Blends

60° Gloss Decrease (%)

Hours in QUV Weatherometer

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500
Gloss Decrease - Acrylic #4 and 50/50 Blends

60° Gloss Decrease (%) vs. Hours in QUV Weatherometer

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500
## Red House Paint Formulation Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solids (Volume)</strong></td>
<td>36%</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>9.0 to 9.5</td>
</tr>
<tr>
<td><strong>Pigment Choice</strong></td>
<td>Organic Red + Phthalo Blue (trace)</td>
</tr>
<tr>
<td><strong>PVC</strong></td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Thickeners</strong></td>
<td>both cellulosic and associative</td>
</tr>
<tr>
<td><strong>60° Gloss Range</strong></td>
<td>50-65</td>
</tr>
<tr>
<td><strong>VOC</strong></td>
<td>1.24 #/gal. or 150 g/liter</td>
</tr>
</tbody>
</table>
Testing procedure # 2:

1) Choose Acrylic Emulsion #3 as blending resin for Red HP formulation.

2) Manufacture of 6 Red House Paint formulations:
   a. Binder = 100% Acrylic Emulsion
   b. Binder = 50% Acrylic Emulsion + 50% FE-4500 (FEVE Emulsion)
   c. Binder = 60% Acrylic Emulsion + 40% FE-4500 (FEVE Emulsion)
   d. Binder = 70% Acrylic Emulsion + 30% FE-4500 (FEVE Emulsion)
   e. Binder = 80% Acrylic Emulsion + 20% FE-4500 (FEVE Emulsion)
   f. Binder = 90% Acrylic Emulsion + 10% FE-4500 (FEVE Emulsion)

3) Preparation of test panels (primed Al panels coated with 4 wet mils of coating)

4) QUV Weatherometer Exposure (UVA 340 Bulbs used)
   a. Test Cycle = 8 hours UV light @ 60°C. + 4 hours condensation @ 50°C.
Gloss Decrease of Acrylic #3 and FE-4500 Blends

- 100% Acrylic
- 10% FE-4500
- 20% FE-4500
- 30% FE-4500

Hours in QUV Weatherometer
Gloss Decrease of Acrylic #3 and FE-4500 Blends

- 100% Acrylic
- 40% FE-4500
- 50% FE-4500

60° Gloss Decrease (%)

Hours in QUV Weatherometer
# FEVE Emulsions in Architectural Coatings

<table>
<thead>
<tr>
<th>White DTM I/M Paint Formulation Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solids (Volume)</strong></td>
</tr>
<tr>
<td><strong>FEVE Emulsion</strong></td>
</tr>
<tr>
<td><strong>pH</strong></td>
</tr>
<tr>
<td><strong>TiO₂ Choice</strong></td>
</tr>
<tr>
<td><strong>PVC</strong></td>
</tr>
<tr>
<td><strong>Thickeners</strong></td>
</tr>
<tr>
<td><strong>60° Gloss Range</strong></td>
</tr>
<tr>
<td><strong>VOC</strong></td>
</tr>
</tbody>
</table>
FEVE Emulsions in Architectural Coatings

**Testing procedure # 3**:

1) Choose 3 different acrylic emulsions from 2 manufacturers as blending resins for White DTM I/M Formulation. These acrylic emulsions are targeted for architectural metal finishes market.

2) Manufacture of 2 *White DTM I/M Paint* formulations:
   a. **Binder = 100% Acrylic Emulsion**
   b. **Binder = 50% Acrylic Emulsion + 50% FE-4300 (FEVE Emulsion)**

3) Preparation of test panels (primed Al panels coated with 4 wet mils of coating)

4) QUV Weatherometer Exposure (UVA 340 Bulbs used)
   a. **Test Cycle = 8 hours UV light @ 60°C. + 4 hours condensation @ 50°C.**
Gloss Decrease of Acrylic #5 and FE-4300 Blend

Hours in QUV Weatherometer

- 100% Acrylic
- 50/50 BLEND w/ FE-4300
Gloss Decrease of Acrylic #6 & FE-4300 Blend

60° Gloss Decrease (%)

Hours in QUV Weatherometer

100% Acrylic
50/50 BLEND w/ FE-4300
Gloss Decrease of Acrylic # 7 and FE-4300 Blend

- 100% Acrylic
- 50/50 BLEND w/ FE-4300

Hours in QUV Weatherometer

60° Gloss Decrease (%)
### Black DTM I/M Paint Formulation Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids (Volume)</td>
<td>36%</td>
</tr>
<tr>
<td>FEVE Emulsions</td>
<td>FE-4300 and FE-4500</td>
</tr>
<tr>
<td>pH</td>
<td>9.0 to 9.5</td>
</tr>
<tr>
<td>Pigment Choice</td>
<td>Tint-Ayd CW5331 Masstone Black</td>
</tr>
<tr>
<td>PVC</td>
<td>2.7</td>
</tr>
<tr>
<td>Thickeners</td>
<td>associative-type</td>
</tr>
<tr>
<td>60° Gloss Range</td>
<td>60-80</td>
</tr>
<tr>
<td>VOC</td>
<td>1.24 #/gal. or 150 g/liter</td>
</tr>
</tbody>
</table>
Testing procedure # 4:

1) Choose Acrylic Emulsion # 5 and Acrylic Emulsion # 6 as blending resins for Black DTM I/M Formulation.

2) Manufacture of 3 Black DTM I/M Paint formulations for each Acrylic:
   a. Binder = 100% Acrylic Emulsion
   b. Binder = 50% Acrylic Emulsion + 50% FE-4300 (FEVE Emulsion)
   c. Binder = 50% Acrylic Emulsion + 50% FE-4500 (FEVE Emulsion)

3) Preparation of test panels (primed Al panels coated with 8 wet mils of coating)

4) QUV Weatherometer Exposure (UVA 340 Bulbs used)
   a. Test Cycle = 8 hours UV light @ 60°C. + 4 hours condensation @ 50°C.
Gloss Decrease of Acrylic #5 and FEVE Blends

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500

Hours in QUV Weatherometer

60° Gloss Decrease (%)
Gloss Decrease of Acrylic #6 and FEVE Blends

60° Gloss Decrease (%)

Hours in QUV Weatherometer

- 100% Acrylic
- 50/50 w/ FE-4300
- 50/50 w/ FE-4500
Testing procedure # 5:

1) Choose Acrylic Emulsion # 5 and Acrylic Emulsion # 6 as blending resins for Black DTM I/M Formulation.

2) Manufacture of 3 Black DTM I/M Paint formulations for each Acrylic:
   a. Binder = 100% Acrylic Emulsion
   b. Binder = 80% Acrylic Emulsion + 20% FE-4300 (FEVE Emulsion)
   c. Binder = 80% Acrylic Emulsion + 20% FE-4500 (FEVE Emulsion)

3) Preparation of test panels (primed Al panels coated with 8 wet mils of coating)

4) QUV Weatherometer Exposure (UVA 340 Bulbs used)
   a. Test Cycle = 8 hours UV light @ 60°C. + 4 hours condensation @ 50° C.
Gloss Decrease of Acrylic #5 and FE-4300 Blends (DTM BLACK FORMULATION)

- 100% Acrylic
- 20% FE-4300

Hours in QUV Weatherometer

Gloss Decrease (%)

- 0.0
- 10.0
- 20.0
- 30.0
- 40.0
- 50.0
- 60.0
- 70.0
- 80.0
- 90.0
- 100.0
Gloss Decrease of Acrylic #5 and FE-4500 Blends (DTM BLACK FORMULATION)

60° Gloss Decrease (%)

Hours in QUV Weatherometer

- 100% Acrylic
- 20% FE-4500
Gloss Decrease of Acrylic #6 and FE-4300 Blends (DTM BLACK FORMULATION)

- 100% Acrylic
- 20% FE-4300

60° Gloss Decrease (%)

Hours in QUV Weatherometer
Gloss Decrease of Acrylic #6 and FE-4500 Blends (DTM BLACK FORMULATION)

60° Gloss Decrease (%)

Hours in QUV Weatherometer

- 100% Acrylic
- 20% FE-4500
Continuation of Project:

1) Testing of 50 g/liter House Paint Formulations

2) Testing of tinted Deep Base DTM I/M Formulation with lower percentages of FEVE emulsions as the binder

3) Testing of Clear Hi-Gloss Concrete Sealer Formulation with the FEVE emulsions replacing a percentage of the acrylic emulsion
Conclusion:

Inclusion of FEVE emulsions in architectural coating formulations can increase gloss retention and therefore prolong the aesthetic properties and the film integrity of these coatings, thereby increasing their life cycle and increasing the time between recoating exterior structures.
Thank you for your Attendance!