

Developments in Fluoropolymer Resins For Long Life Coatings

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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

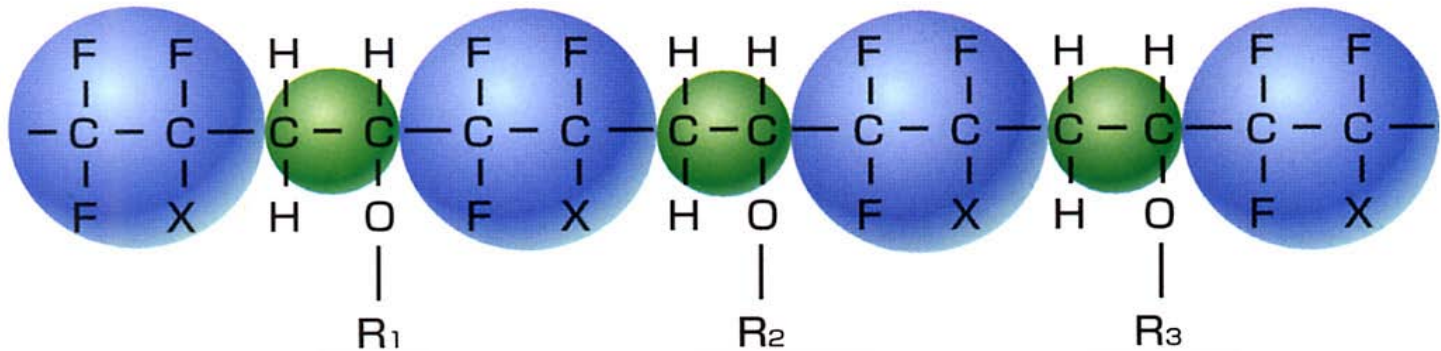
Fluoroethylene Vinyl Ether (FEVE) Resins



Fluoro Ethylene



Vinyl Ether



FLUORINATED SEGMENTS: Weatherability, durability, chemical resistance

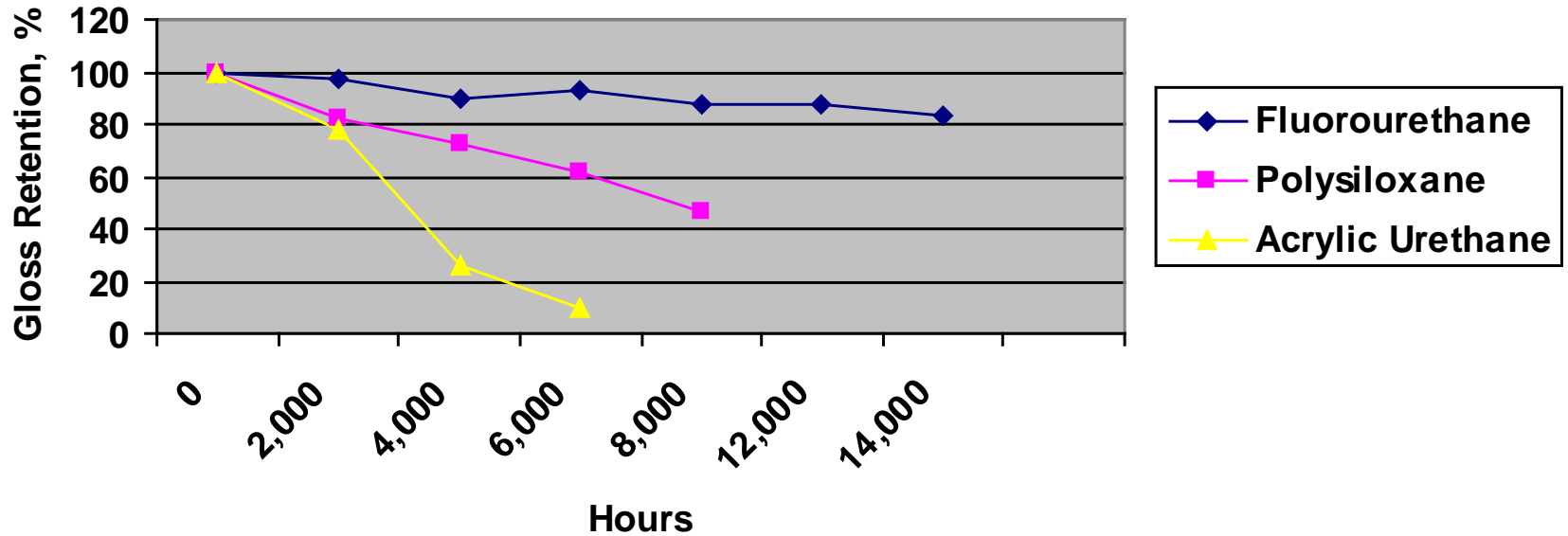
VINYL ETHER SEGMENTS: Gloss, solubility, crosslinking

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

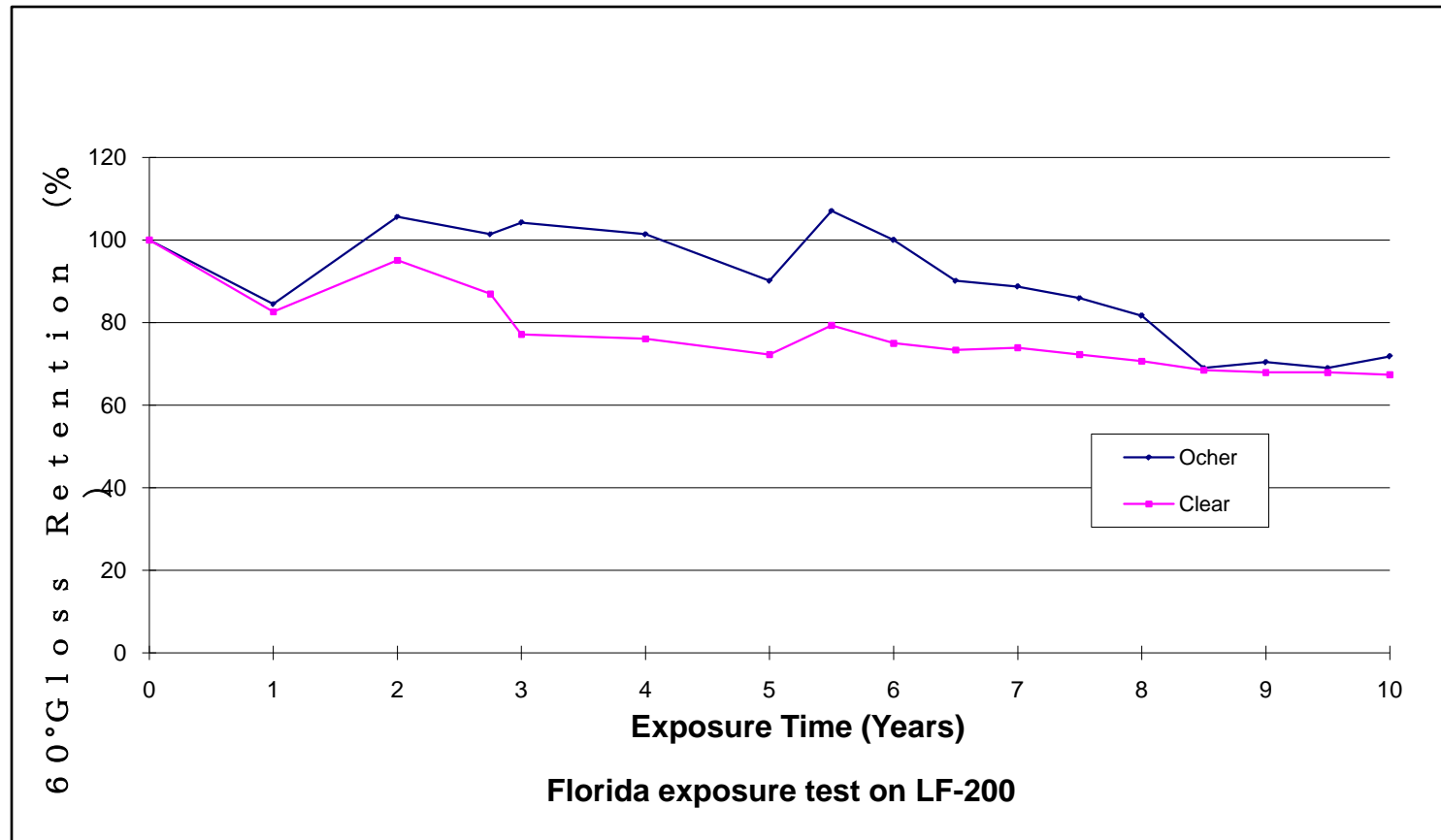
Weathering of FEVE Coatings

QUV-A Test (ASTM D4587)



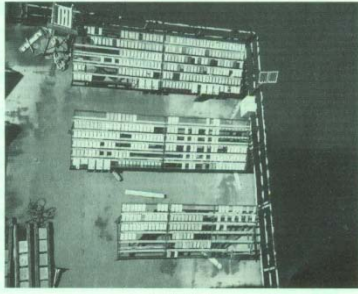
Weathering of FEVE Resin Topcoats

South Florida Weathering





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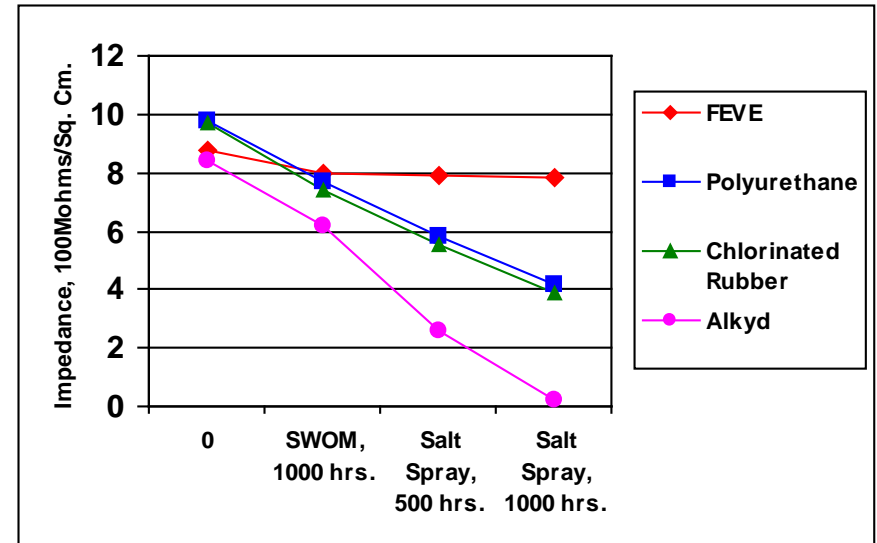
Comparative Weathering of Fluorourethane Topcoat

| Test Site | Test Duration Years | Topcoat Type | Initial μm | Final μm |
|---------------|------------------------|---------------------|--------------------------|------------------------|
| Suruga Bay | 16 | Acrylic Urethane | 25 | 0 (13 yrs.) |
| Suruga Bay | 16 | Fluoro- Urethane | 25 | 21 |

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

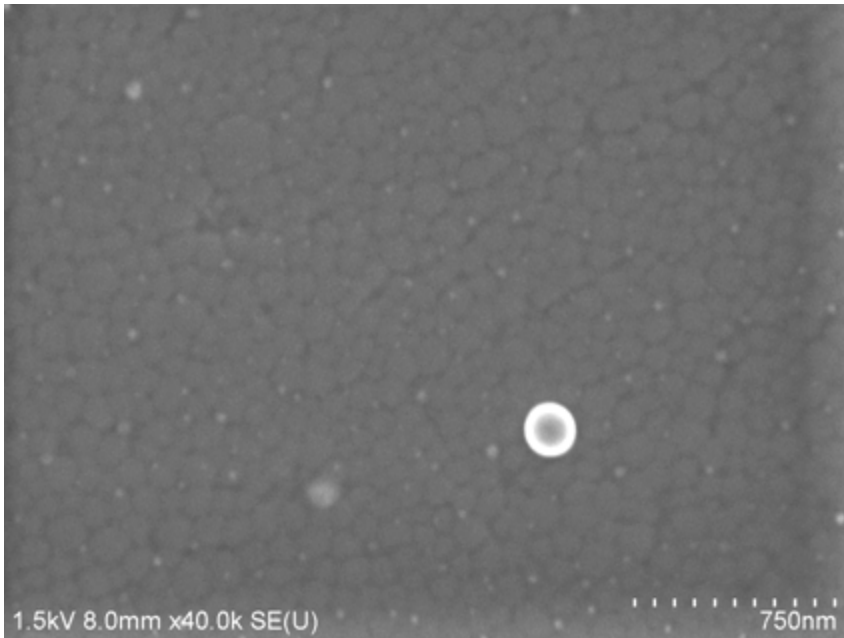
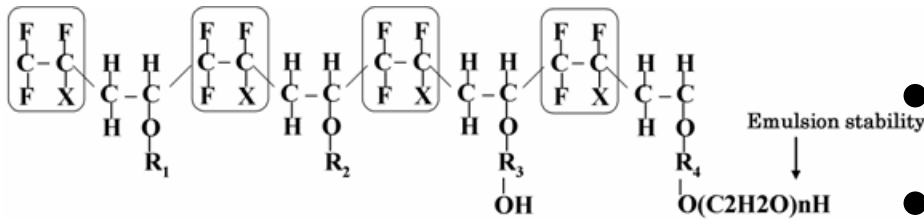
- **Solvent-Based**
 - Dissolved in xylene
 - Difficult to meet VOC/HAPS regulations
- **Develop New Resin Forms For New Standards**
- **Solid Resins**
 - Powder coatings
- **Water Emulsions**
- **New Water-Based Resin**

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**



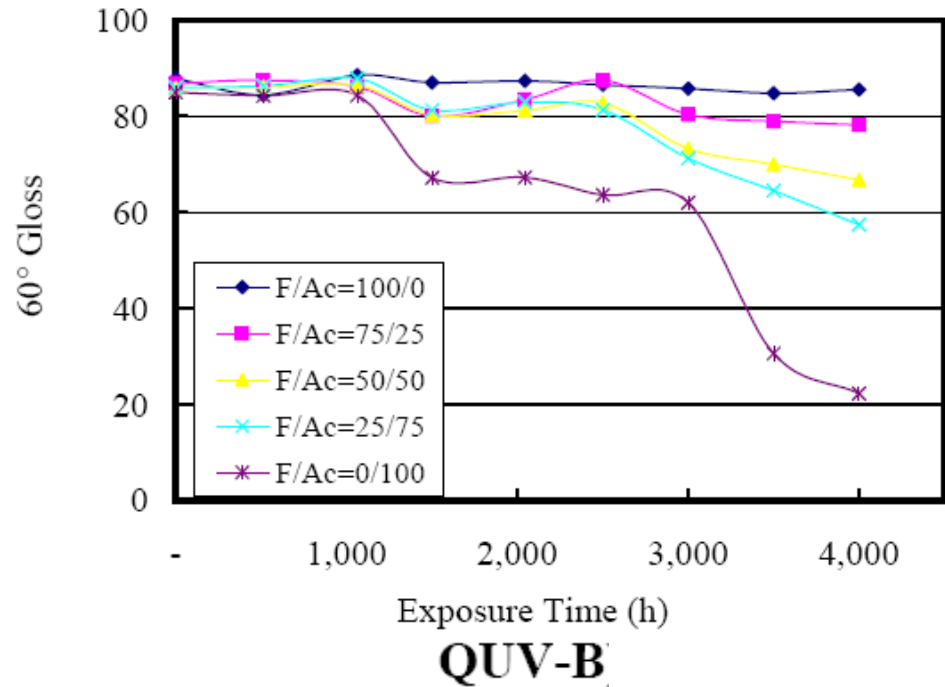
FEVE Water Emulsions



- 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)

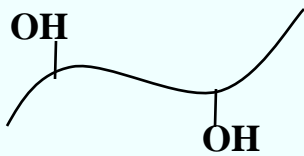
FEVE Water Based Resins

- **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**

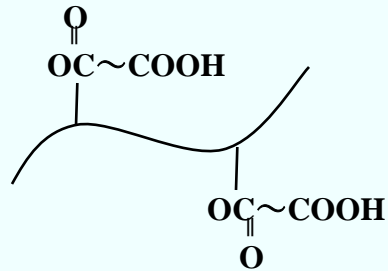
FEVE Water Dispersions

Producing Dispersions

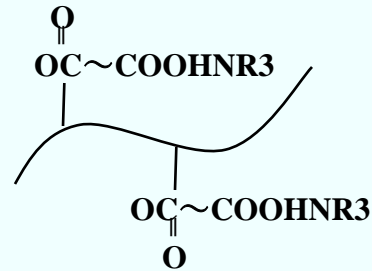
**Solid
FEVE resin**



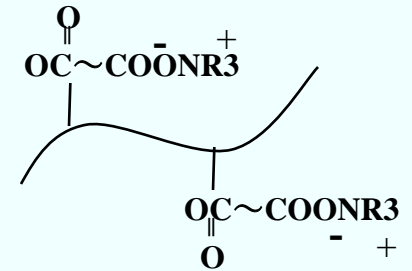
**Acid
modification**



**Neutralized
by amine**



**Water added
& Solvent volatized**



In solvent

In water

FEVE Water Dispersions

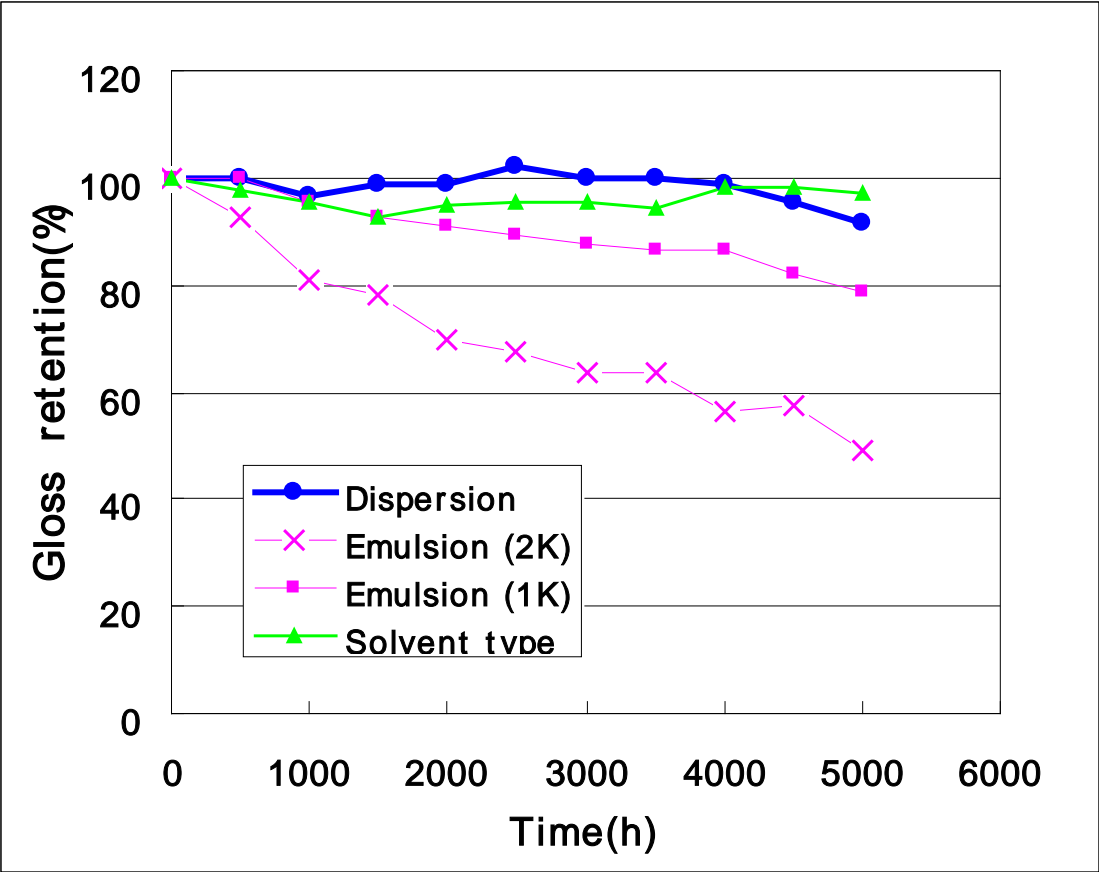
Typical Physical Properties

| Physical Property | Value |
|--|--------------------|
| Appearance | Milky White Liquid |
| Solids, wt. % | 40% |
| pH | 7.4 |
| Particle Diameter, μm | 145 |
| Minimum Film Forming Temperature, $^{\circ}\text{C}$ | 27 |
| Acid Value, mg KOH/g-polymer | 15 |
| Hydroxyl Value, mg KOH/g-polymer | 85 |

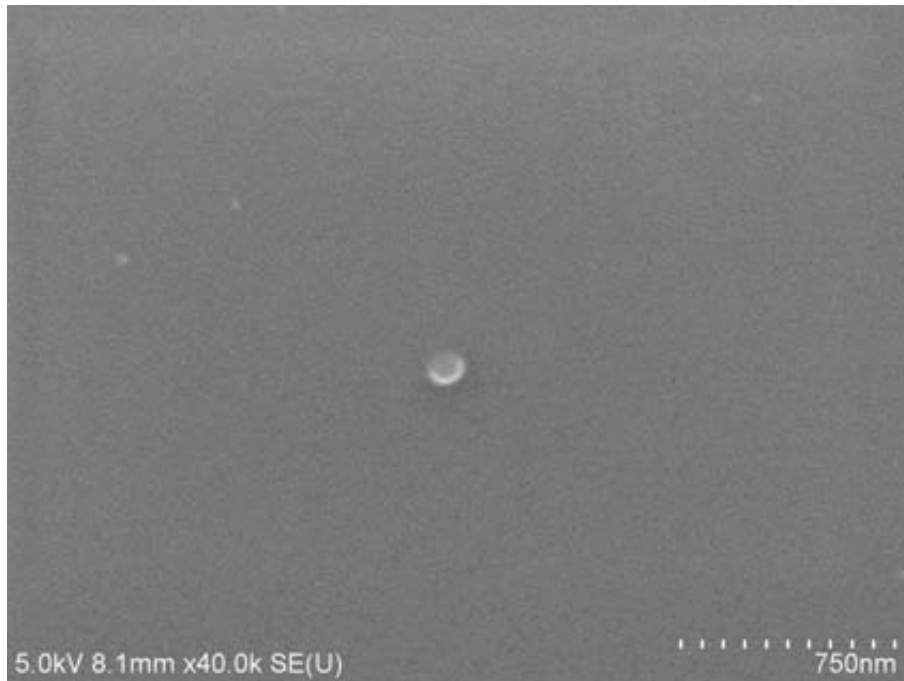
Properties of FEVE Dispersion Coatings

| Property | Test Method | | FEVE Dispersion, 2K | FEVE Emulsion, 2K | FEVE Solvent, 2K |
|--------------------|---|---------------------|---------------------|-------------------|------------------|
| Gloss, 60° | ISO 2813 | | 88 | 78 | 90 |
| Pencil Hardness | ASTM D 3363 | Gouge | 4H | 4H | 3H |
| Pendulum Hardness | ASTM D 4366 | | 79 | 75 | 80 |
| Impact Resistance | ASTM D 2794 Diameter=0.5" | Intrusion 0.5 kg | >1.0 | 1.0 | >1.0 |
| | | Extrusion 0.5 kg | >1.0 | 1.0 | >1.0 |
| Cross Cut Adhesion | ASTM D 3359 | | 5B | 5B | 5B |
| Water Resistance | ISO 2812, 40 C, 24 h Cross Cut Adhesion Blistering | | 4B | 3B | 5B |
| | | | No blistering | Medium blisters | No blistering |

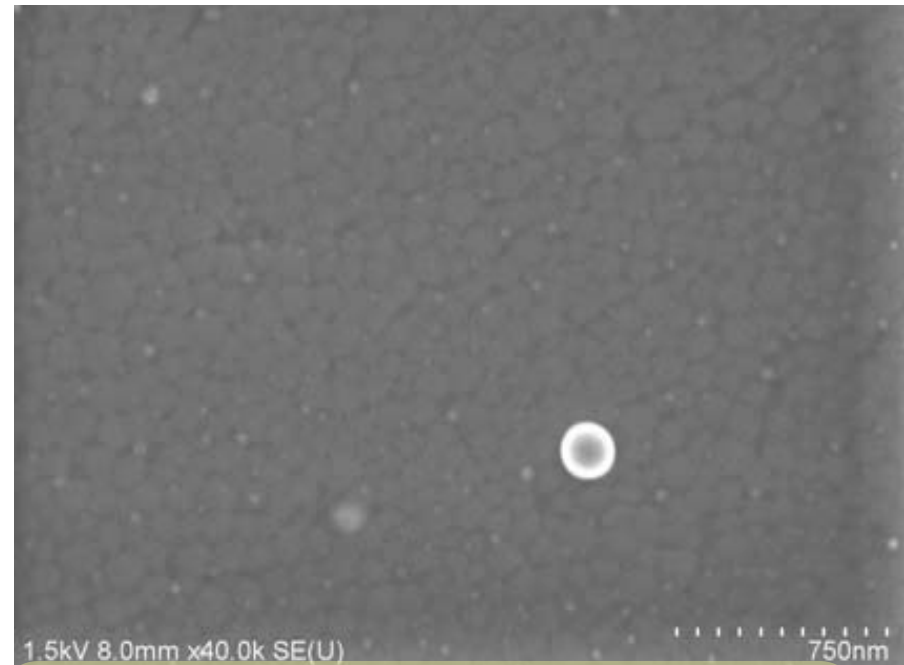
Comparative Weathering of FEVE Water Dispersions (QUV-B)



SEM: FEVE Dispersion vs. Emulsion



Dispersion



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



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Applications for FEVE Coatings



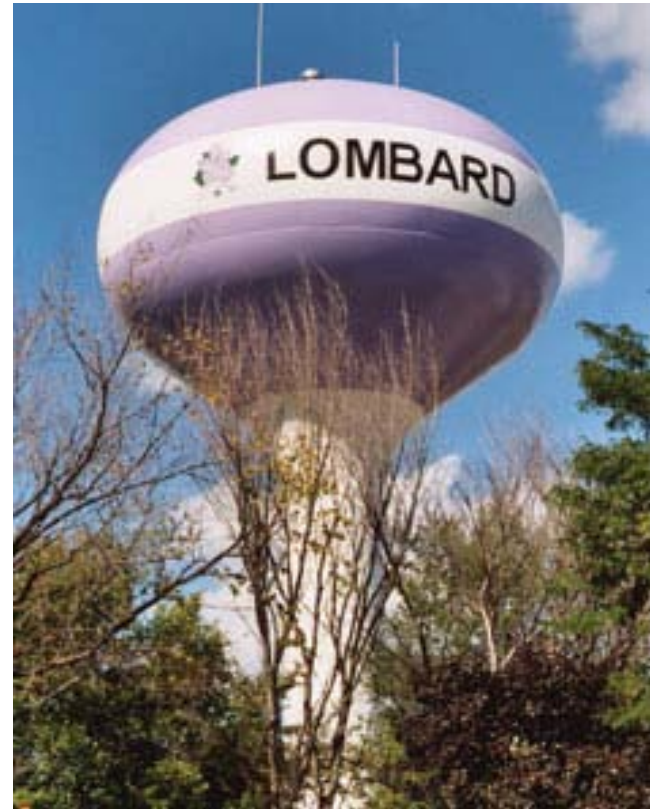
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Applications for FEVE Coatings



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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**