Powder Coating Preparation: Control of Surface Defects for FEVE Resin Systems





Connie Przeslawski

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FEVE Chemistry



Alternating copolymers synthesized via radical polymerization



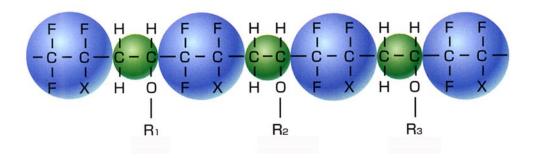
Amorphous structure



FEVE resins are the 'backbone' or binder resins



Hydroxyl groups scattered through the FEVE backbone



<u>F</u>luoro<u>e</u>thylene <u>V</u>inyl <u>E</u>ther

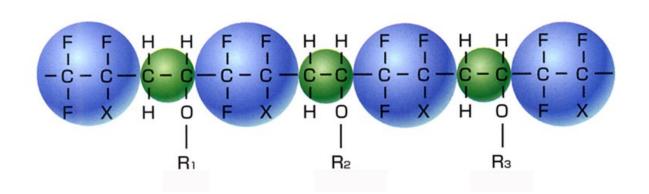
FLUOROETHYLENE

- Weatherability
- Durability
- Chemical Resistance

VINYL ETHER

- Gloss
- Solubility
- Crosslinking

FEVE Chemistry: Bond Energy



- > UV radiation in sunlight contains enough energy to break chemical bonds
- > C-F bond energy is stronger than UV radiation energy
- > C-F bonds provide additional 'protection' for vinyl ethers

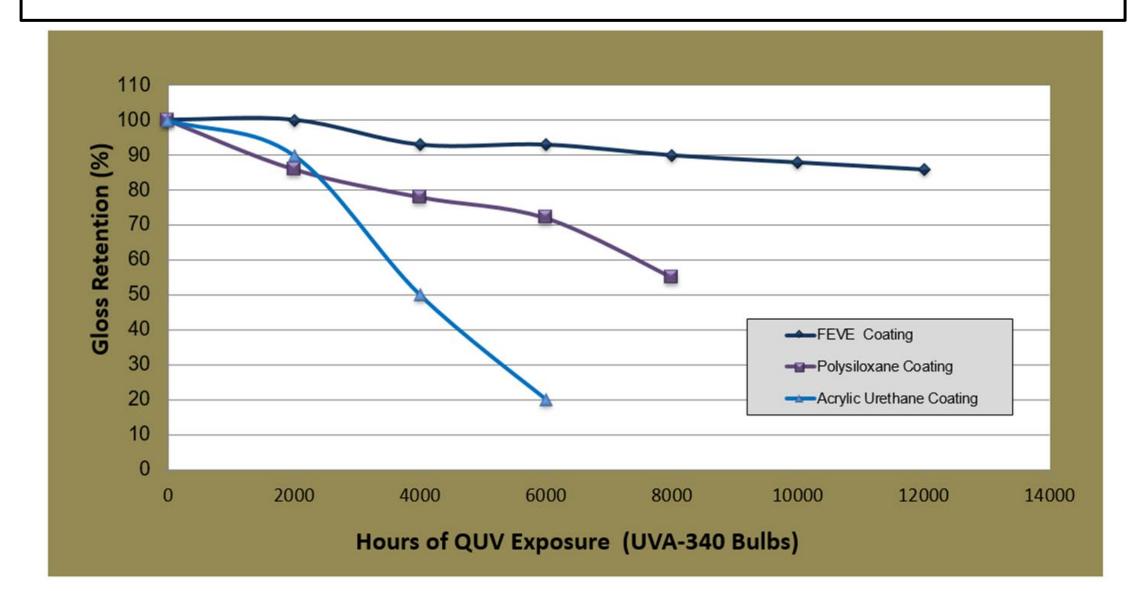
Bond Energies

Bond Type	ΔH _{f,298K} (kJ/mol) [Indirect Bond Strength]
C-F	536
C-O	380

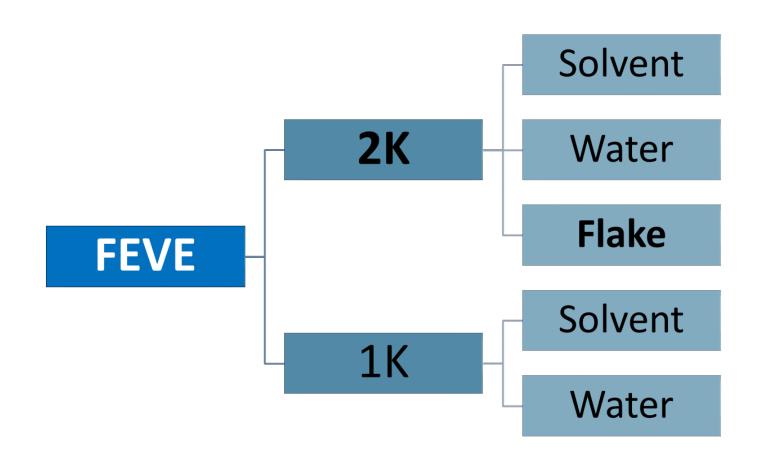
Solar Energies

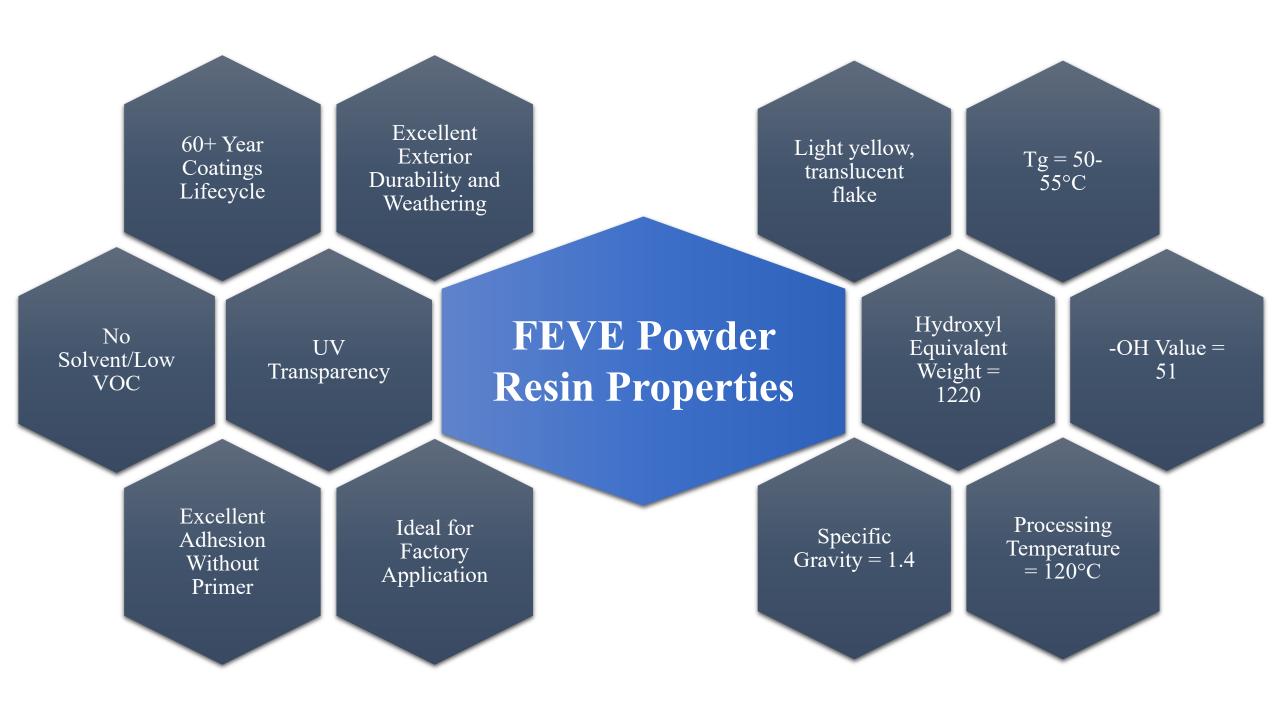
Group	λ (nm)	Energy (kJ/mol)
Vis	780-400	150-300
UVA	400-315	300-380
UVB	315-280	380-430

FEVE Coatings: Accelerated Weathering



FEVE Resin Grades





Extrusion Conditions

Formula Design

Formulating and Weigh Measuring Processing and Milling Extrusion and Mill/Sieve Spray and Substrate Application

Curing

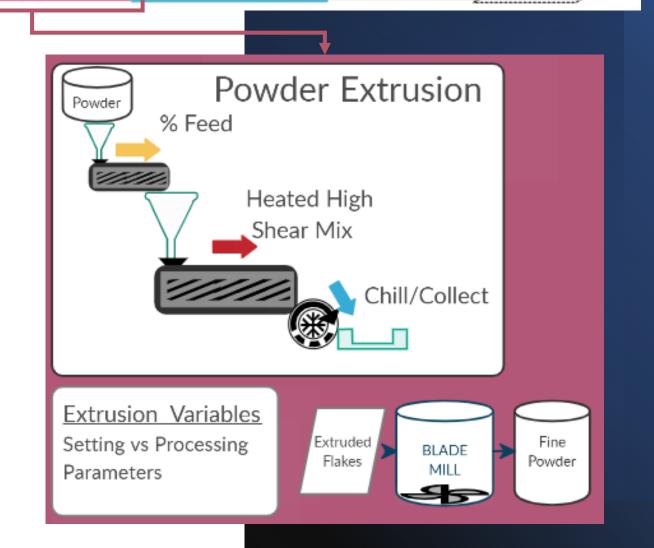
Testing
and
Results

Setting Parameters (before extrusion)

- Throughput/feed rate (%)
- Screw speed (RPM)
- Screw profile
- Barrel zone temperatures
- Formulation chemistry

Process Parameters (during extrusion)

- Torque
- Pressure/filling degree profile
- Temperature profile
- Residence time
- Dispersion/distribution mixing quality



Types of Paint Coating Testing

Natural Weathering

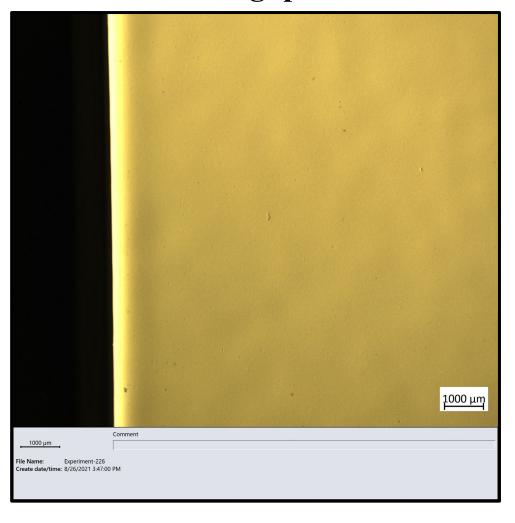
Accelerated Weathering

Chemical/ Physical Testing

Surface Appearance Electrochemical Measurements

Microscope Imaging of FEVE Systems

Maximum throughput/barrel feed

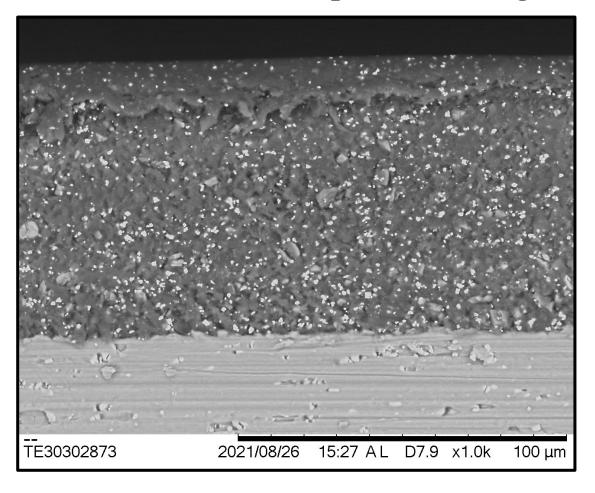


50% throughput/barrel feed

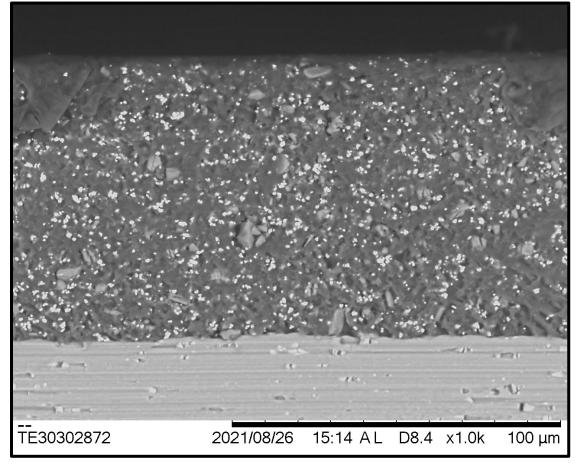


SEM Cross Section of FEVE Systems

Lower RPM, lower dispersive mixing

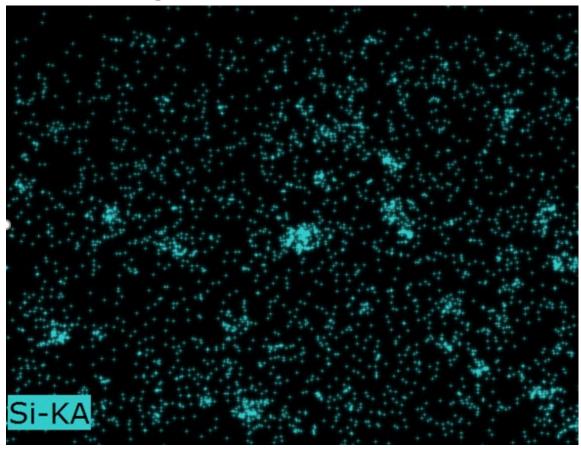


Higher RPM, higher dispersive mixing

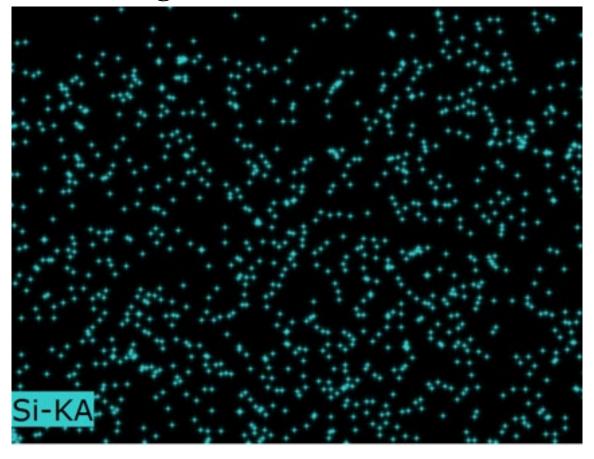


SEM-EDX Cross Section of FEVE Systems

Lower RPM, lower dispersive mixing 1000x Magnification



Higher RPM, higher dispersive mixing 1000x Magnification

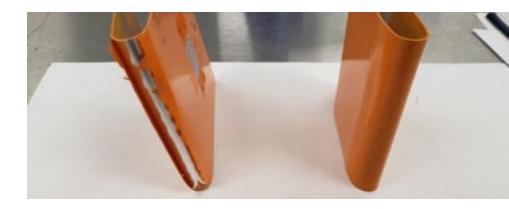


Processing Conditions: Physical Properties

- Adjustments in processing can eliminate surface defects and improve physical performance
- Processing parameters are essential to final performance of coating
- Formulation chemistry is critical



Left: Maximum throughput/barrel feed Right: 50% throughput/barrel feed



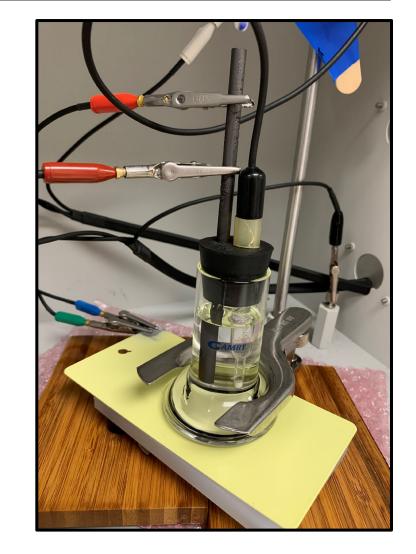
Left: Lower RPM/lower dispersive mixing Right: Higher RPM/higher dispersive mixing

EIS: Coating Capacitance & Water Uptake

- ➤ Rapid Electrochemical Assessment of Paint (REAP)
- ➤ Water volume uptake via coating capacitance determination

$$\gg$$
% volume = 100 log(Cct_0 / Cc_{t24})/log(80)*

- $ightharpoonup Cc_{t0}$ = Coating capacitance (initial time)
- $ightharpoonup Cc_{t24}$ = Coating capacitance (after 24-hour soak)
- Highly controlled testing environment
- ➤ One of many electrochemical test methods used to quickly evaluate coating properties



^{*} Brasher, Kingsbury

Lower RPM/lower dispersive mixing

Higher RPM/higher dispersive mixing

1.97%

Water Uptake

1.52%

Water Uptake

5%

% Impedance Change

2%

% Impedance Change

Extrusion processing parameters affect surface appearance and physical properties of the film coating



- 1. Higher RPM/Shorter Residence Time
- 2. Maximum Throughput/Barrel Fill

- -Improved extrusion mixing
- -Smoother surface appearance
- -Improved physical properties
- -Lower water uptake
- -Faster material extrusion



- 1. Lower RPM/Longer Residence Time
- 2. Lower Throughput/Partial Barrel Fill

- -Poor extrusion mixing
- -Rough surface appearance
- -Poor physical properties
- -Higher water uptake
- -Slower material extrusion

Future Work

- Formulation chemistry
- Processing conditions
- Screw profiles
- Thermal analysis and physical testing
- Additional EIS evaluations
- Accelerated weathering and natural weathering





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