SURFACTANT LEACHING TEST METHOD DEVELOPMENT

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Engineered Polymer Solutions

Surfactant Leaching Problem

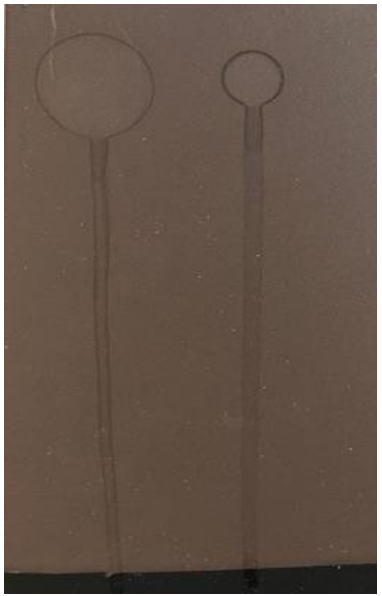
- **Occurs when surfactants and other hydrophilic components (often low MW) migrate to the film/air interface**
  - Film/substrate interface accumulation leads to loss of adhesion, blistering, etc
  - Aesthetic Failure: Spotting, Snail-trail
- **Multi-faceted Problem**
  - Materials Effects
    - **Resin: emulsion stabilizers and surfactants**
    - Formulation: surfactants and dispersants, PVC
    - Colorant: universal v waterborne, POS Tinting v In-plant
    - Substrate Effect? Water permeability?
  - Applications Effects
    - Curing Condition: Temp/Humidity
    - Mil thickness
    - Length of Cure
    - Length / Severity of Exposure

Testing for Surfactant Leaching Resistance

- Poor correlation between common lab tests
- Poor correlation to real-world performance

100% Relative Humidity Test (ASTM 2247)

Cleveland Condensing Test (ASTM 4585)



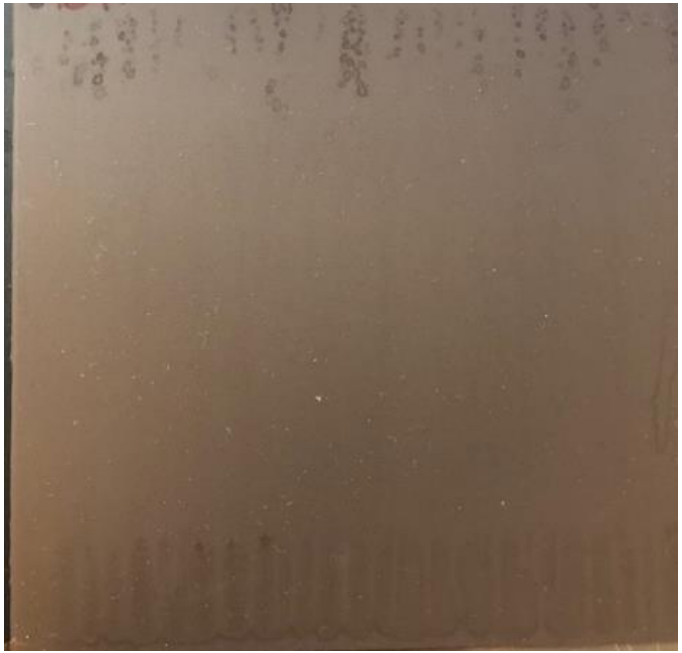
Water Spot Test (ASTM 7190)

Exterior Exposure Testing

Surfactant Leaching Resistance Development

- **Reliance on lab tests can be misleading**

Spot Test



Condensation Test

Exterior Exposure

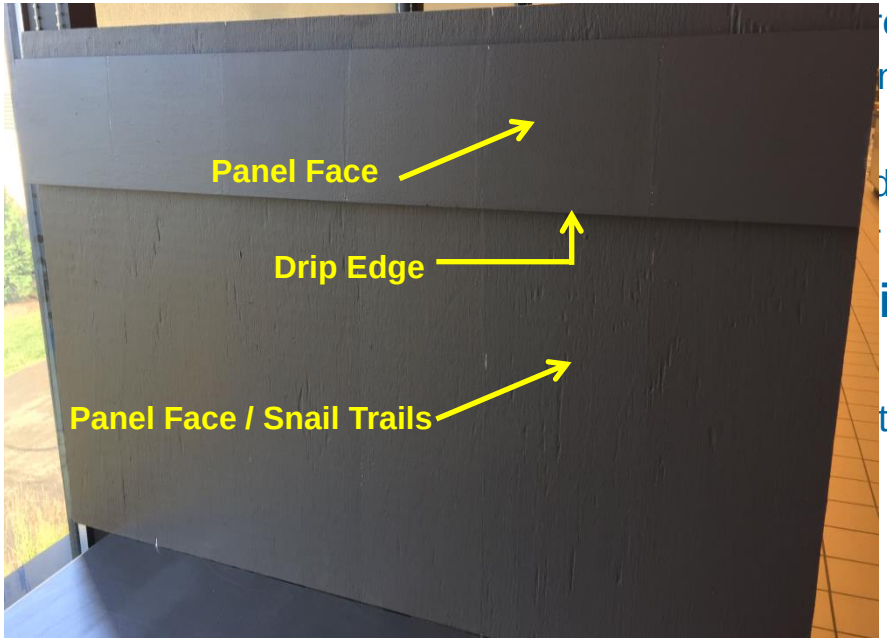
Surfactant Leaching Resistance Development

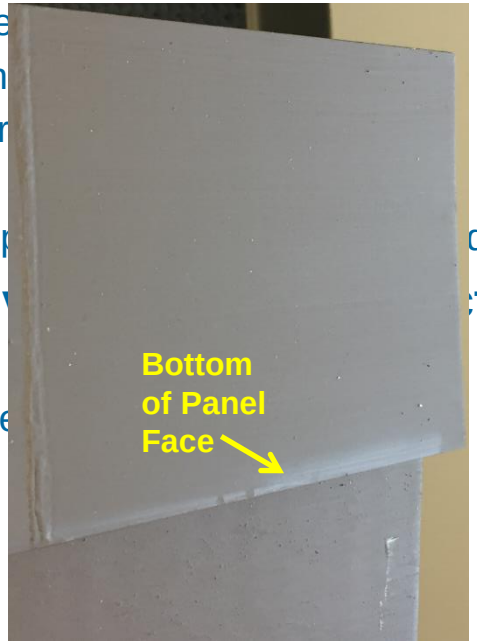
Relying on spot test may lead to overlooking a good prototype candidate

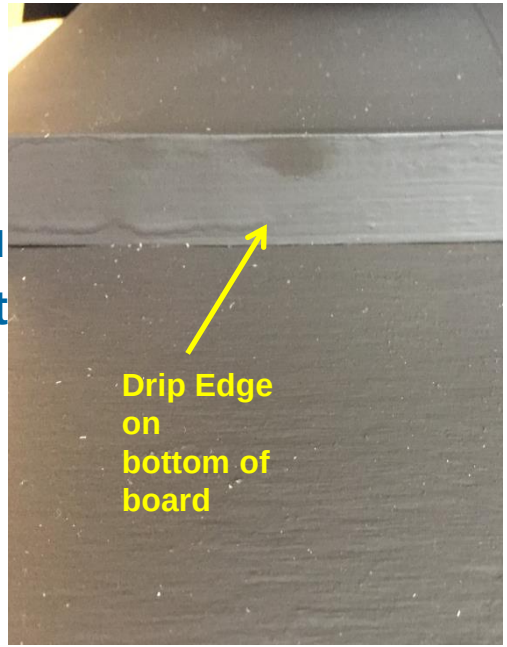
Surfactant Leaching Resistance Development

Project Objectives:

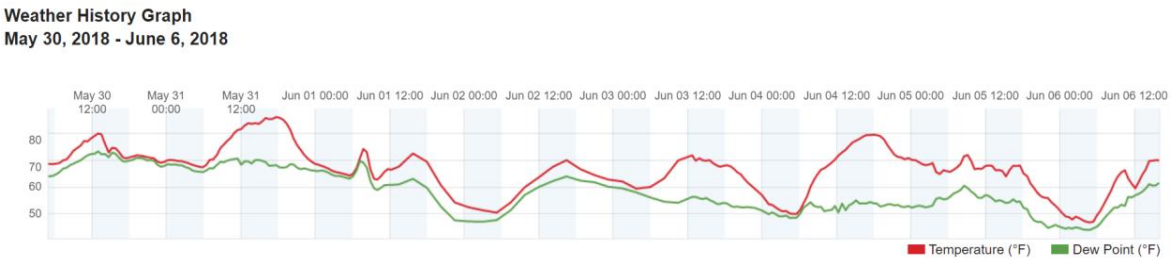
- Develop a lab test procedure that correlates to actual exterior exposure results







Gathering Data – Spring

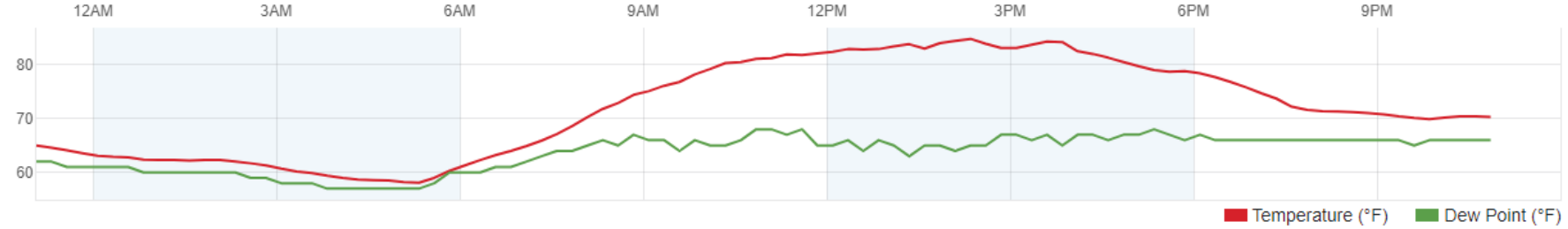


- **Taming mother nature**
  - Initially difficult to identify cause of failure and severity
  - Inconsistent & unpredictable weather
- **Profiling polymer performance**
  - Strengths and weaknesses in dynamic conditions

Gathering Data – Summer

Weather History Graph
July 25, 2018

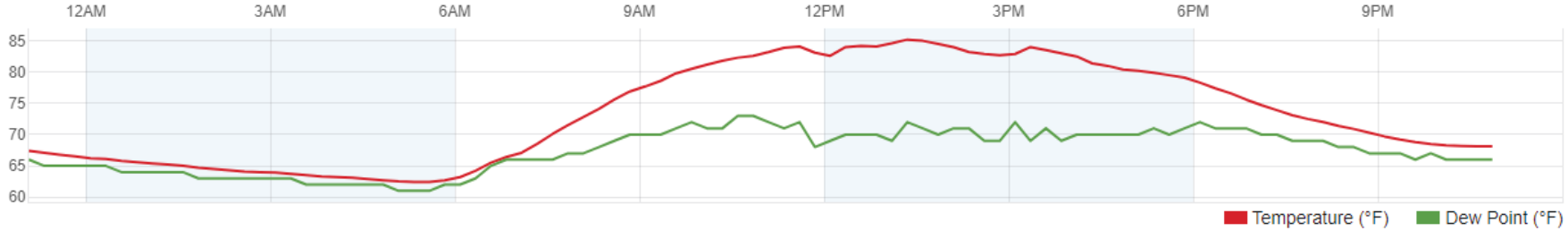
Low Temp: 59.5
Relative Humidity: 95%

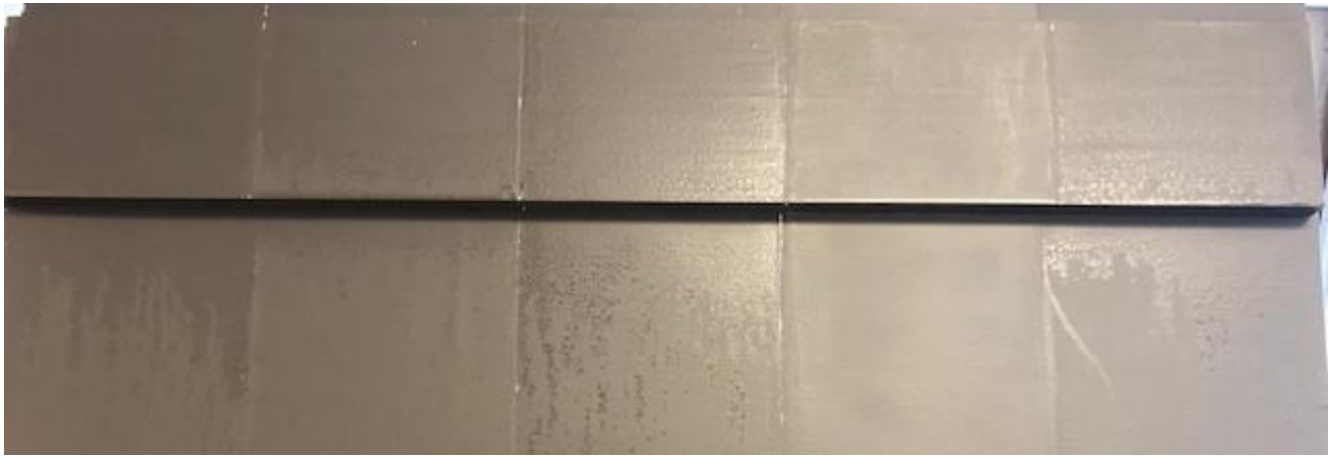


Gathering Data – Late Summer

Weather History Graph
August 14, 2018

Low Temp: 62.4
Rel Humidity: 97%

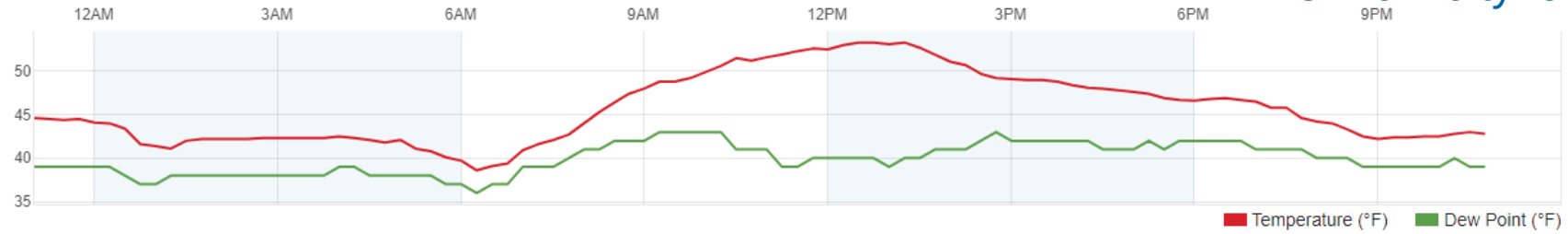




Gathering Data – Autumn

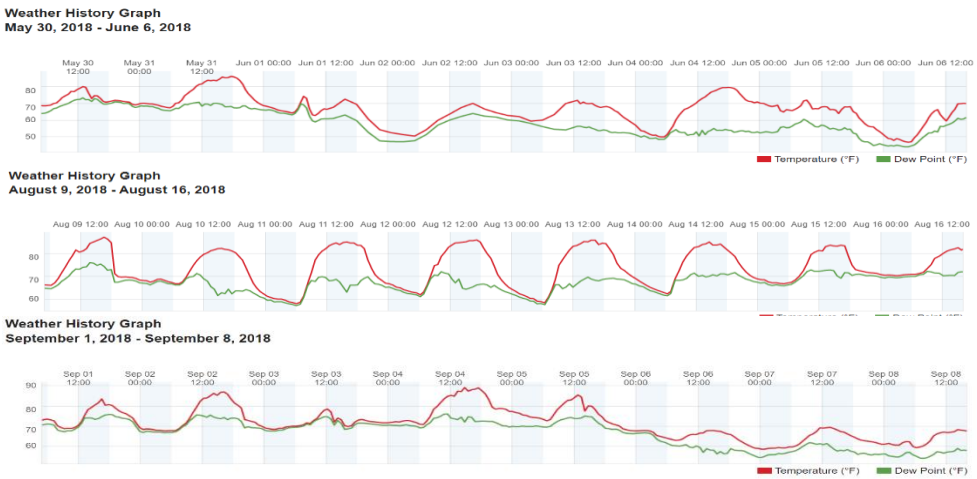
Weather History Graph
October 27, 2018

Low Temp: 36.0
Rel Humidity: 92%

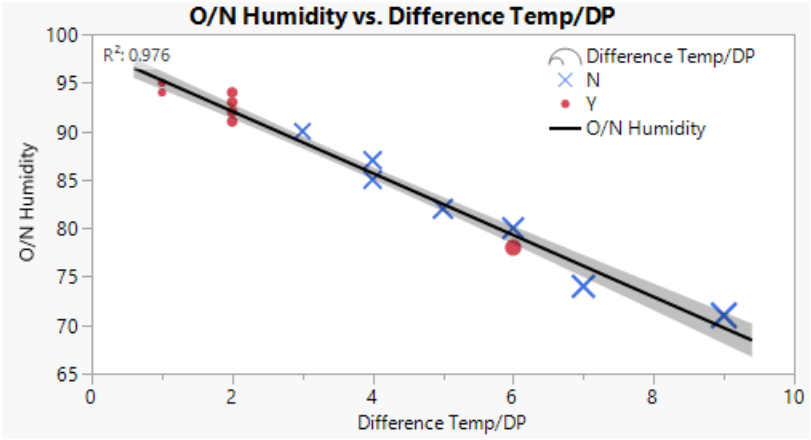


Identifying Factors

Day-to-Day Weather Variability



Temperature and Dew Point Convergence as Critical Condensation Factor

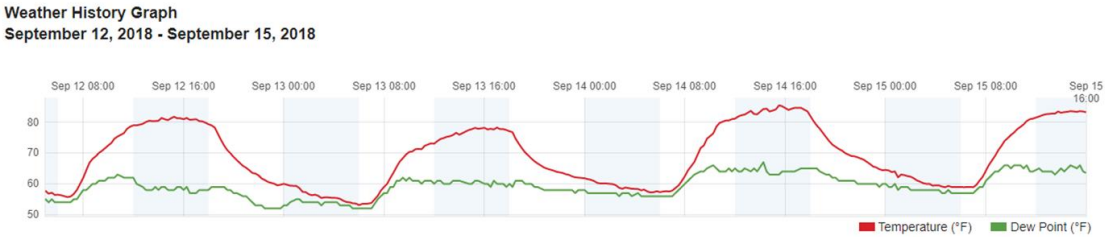


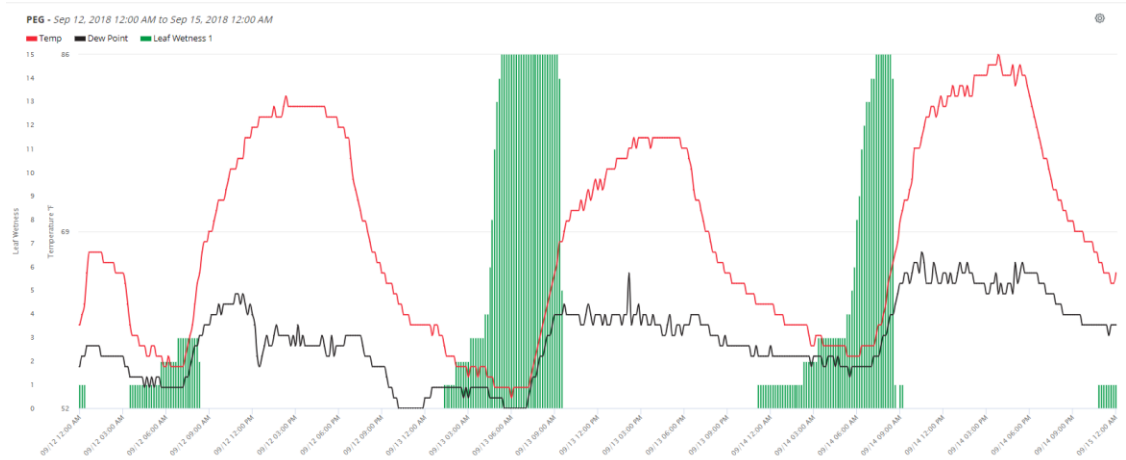
Main Factors for Exterior Leaching:

- Temperature and humidity relation to the dew point
- Convergence of temperature and dew point predictably leads to condensation and likelihood of surfactant leaching failures

Identifying Factors

- **What drives variability?**
  - Length of Wetness Exposure



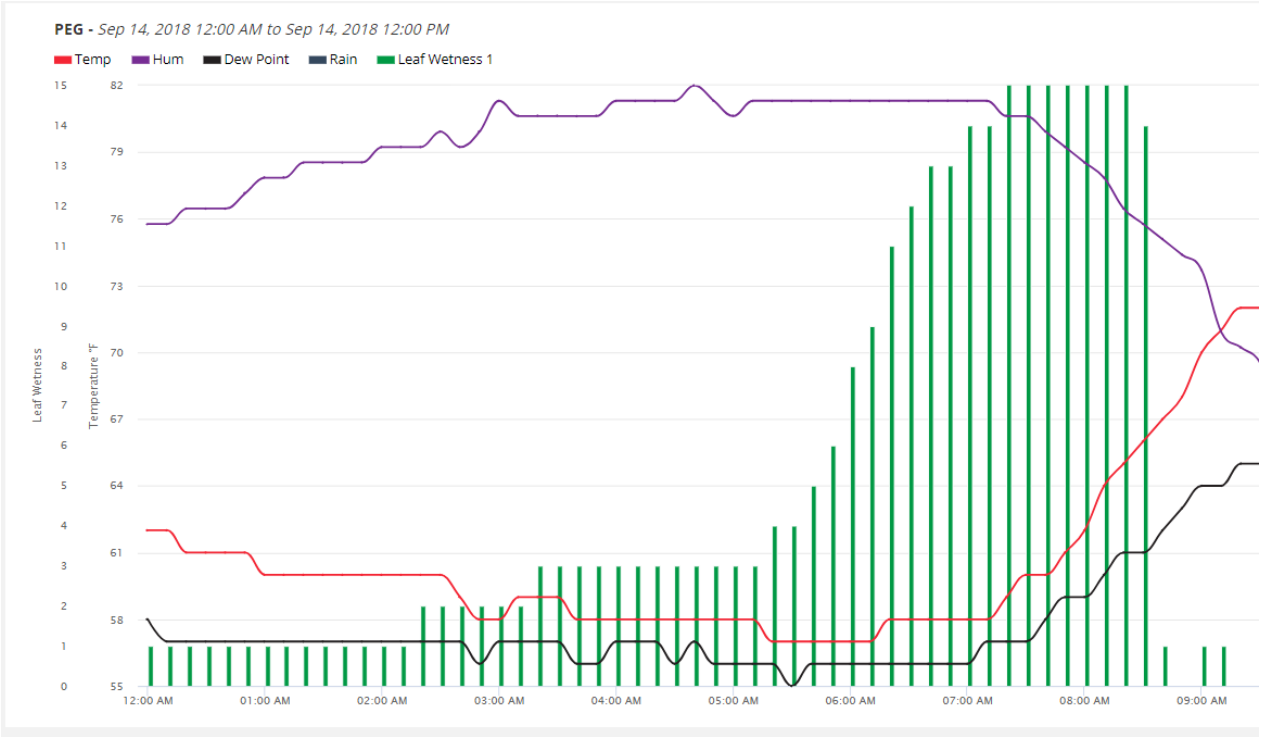


Identifying Factors

- **Identification of conditions for leaching**
  - Dew point: the temperature at which condensation will form
    - As temperature falls, relative humidity rises and reaches 100% at dew point
    - Capacity for air to hold water; low dew point – less moisture
    - Below dew point, water leaves the air
    - Substrate surface temperature
  - Surface Wetness
    - Total exposure time

Replicating Conditions for Leaching

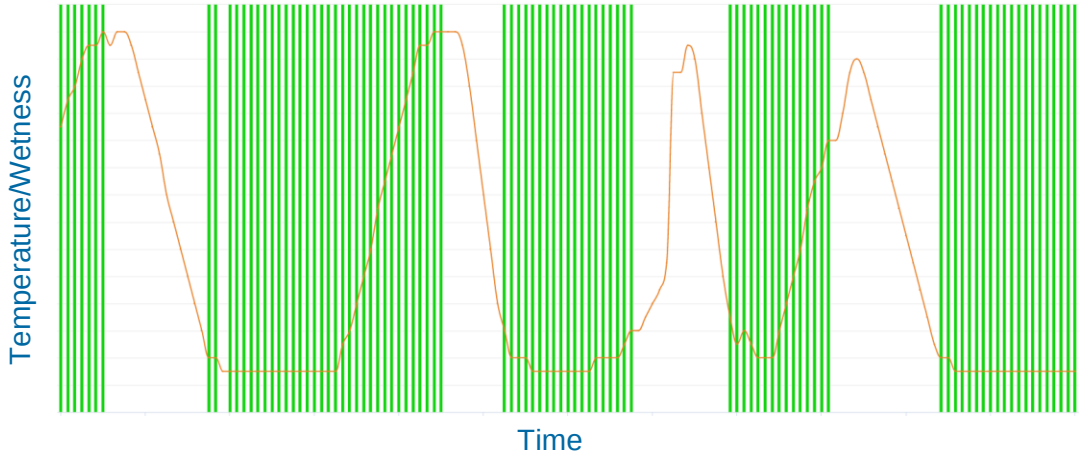
- Extensive exterior data set to model leaching conditions
- Dew point and temperature convergence
- Wetness timescales
- “Morning Dew” cycle



Replicating Conditions for Leaching

EPS temperature/humidity chambers

- Use data from exterior testing to model and simulate real-world conditions
- Ability to probe robustness and resistance to leaching at varying parameters
    - Simulated dew points
    - Temperature ramp rates
    - Length of surface wetness



Exterior Performance Validation

- **Excellent correlation to real-world performance**
- **Beveled siding**
  - Drip edge
  - ‘Snail trail’ area
- **Ability to recreate dynamic condensation events “on-demand”**
- **Confidence in product development**
  - Polymer attributes
  - Paint formulation parameters

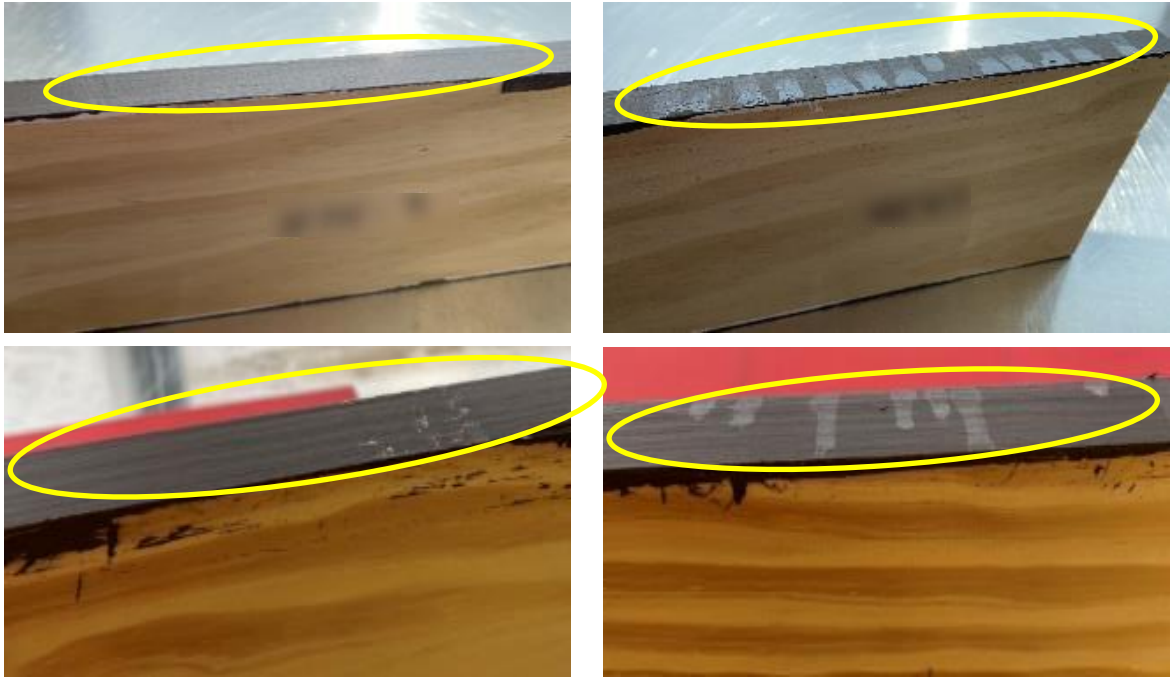
Comparison of Accelerated (top) and Exterior Exposures (bottom)

Exterior Performance Validation

Exterior Performance Validation

Exterior Exposure

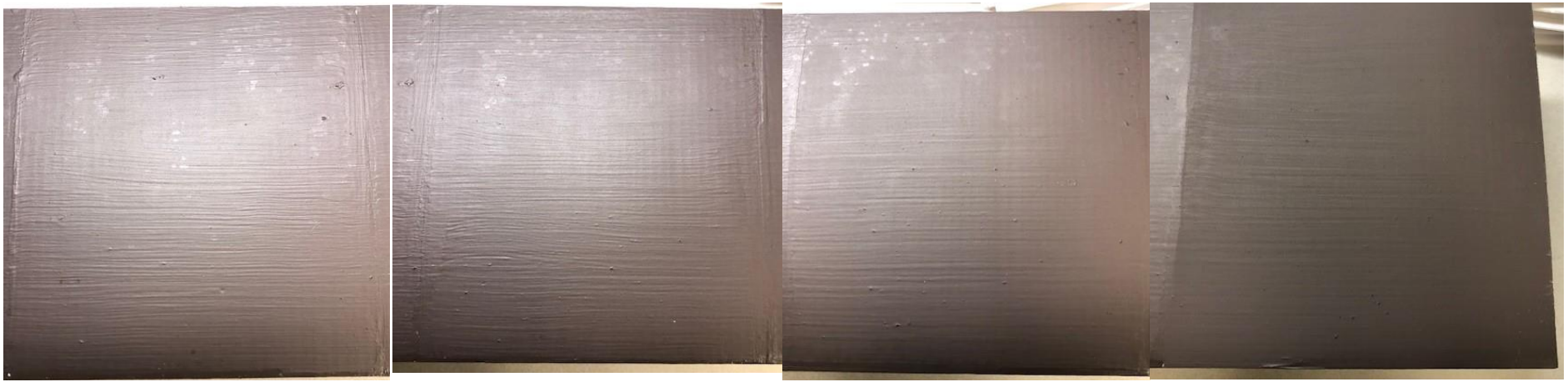
Accelerated Test



Confidence in Product Development

- **Screening Formulation Robustness**
  - Minimizing hydrophilic components
  - Formulation additives
  - Formulating near critical PVC

ADT	1.75 CPVC	1.63 CPVC	1.5 CPVC	1.25 CPVC
60° Gloss	3.60	2.60	2.20	1.10
85° Gloss	4.80	3.20	2.70	1.80



Surfactant Leaching Resistance Development

Project Objectives:

- ✓ **Develop a lab test procedure that correlates to exterior exposure results**
  - Reproducible condensation events to evaluate leaching resistance
  - Dynamic test with more insight and correlation than traditional methods
  - Manipulate dewpoints to influence severity of exposure and probe robustness during development
  - Ability to focus on polymer attributes and paint formulation screening
- ✓ **Develop polymer prototype to deliver real-world surfactant leaching resistance**
  - Excellent exterior performance as anticipated
  - Wide formulation latitude
  - Maintenance of key exterior properties

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