

SPECTROSCOPIC ANALYSIS OF ARCHITECTURAL COATINGS FOR IMPROVED WEATHERING

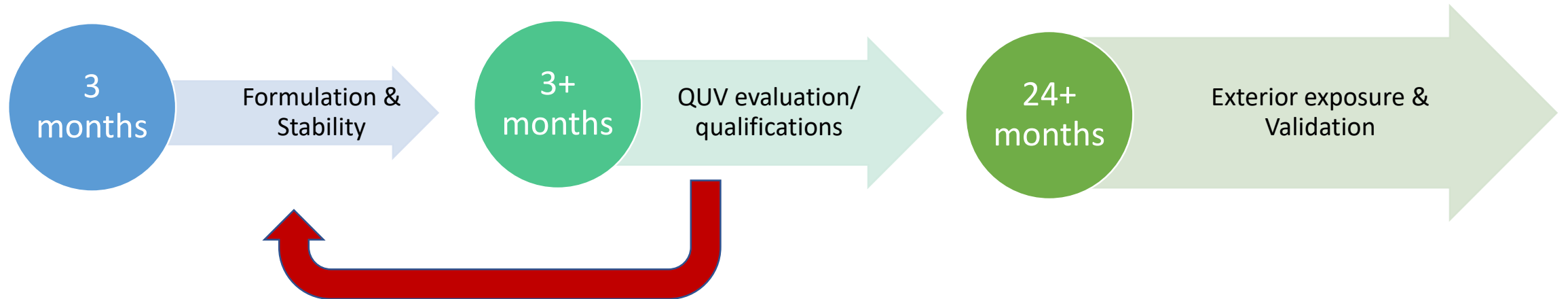
Karl Booth

Western Coatings Show

October 23, 2019



Exterior Product Development Pain Points



Exterior Exposure

- Gold standard for product validation
 - Dirt pickup
 - Grain crack
 - Adhesion
 - **Gloss retention**
 - Mildew

- Disadvantages

- Multi-year investment
- Variability within and between studies



EPS Exposure Program



Los Angeles, CA

Marengo, IL

Ft Myers, FL

Exposure Study for Gloss Retention

Main objectives:

1. Identify the conditions that are most challenging to gloss retention performance.
2. Identify conditions that are most stable, consistent and reproducible.



Polymer	Substrate	Location	Color
1	Primed Aluminum	California	White
2	Primed Cedar	Florida	Yellow Oxide
3	Galvanized	Illinois	Lamp Black
4	Primed Hardie		
5	Bare Aluminum		
6	SYP		
7			

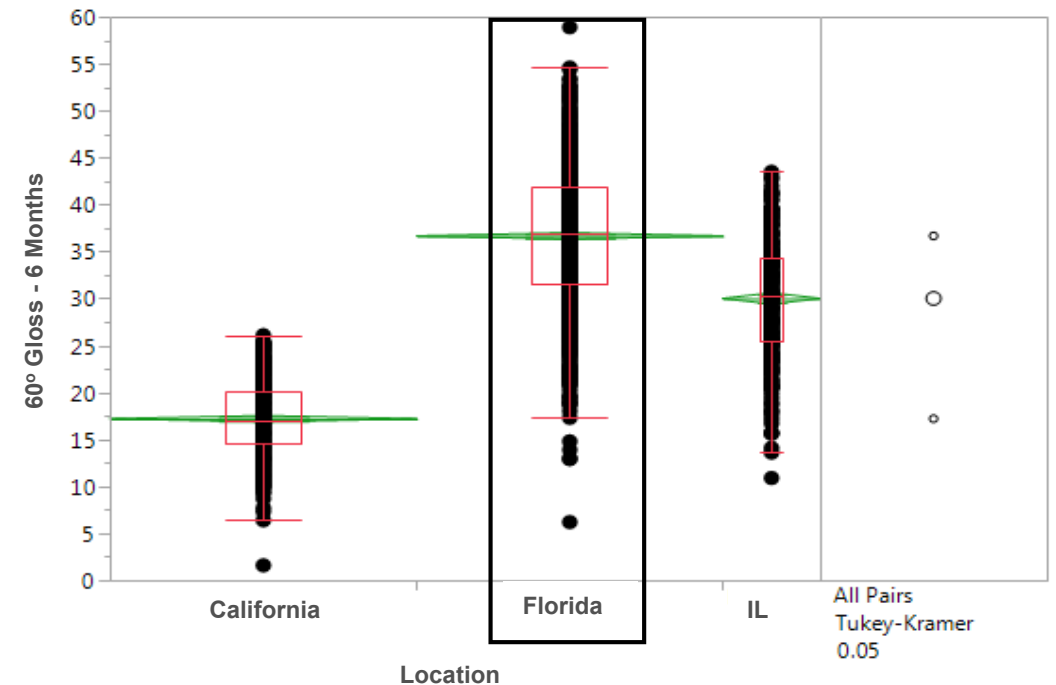
- ❖ Paints were all <50 g/L and adjusted to pass LTC
- ❖ 972 individual panels
- ❖ 3,400 readings taken over 6 months

Exposure Study for Gloss Retention

Location Selection

- Florida shows the largest variation, highest mean
- California shows lowest gloss
 - Gloss evaluated both washed & unwashed
 - Dirt pickup responsible for gloss reduction

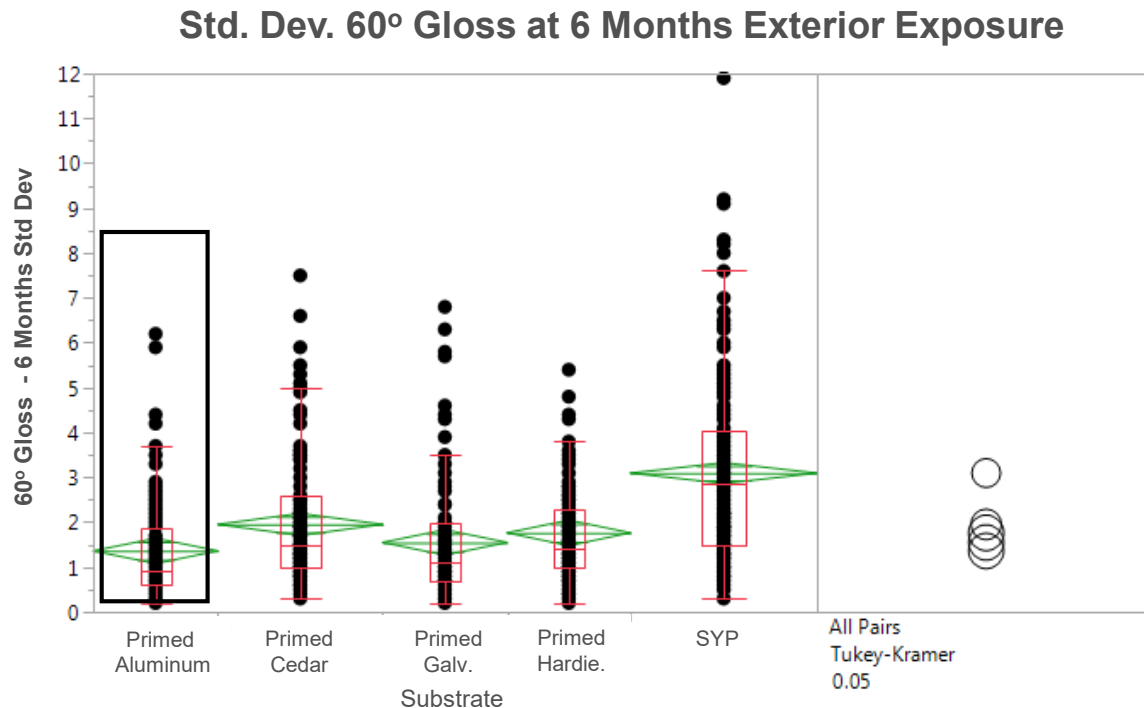
Sample	Mean	Std. Dev	Grouping		
California	17.2	3.7	A		
Florida	36.7	7.3		B	
Marengo	30.0	6.1			C



Exposure Study for Gloss Retention

- **Substrate Selection**

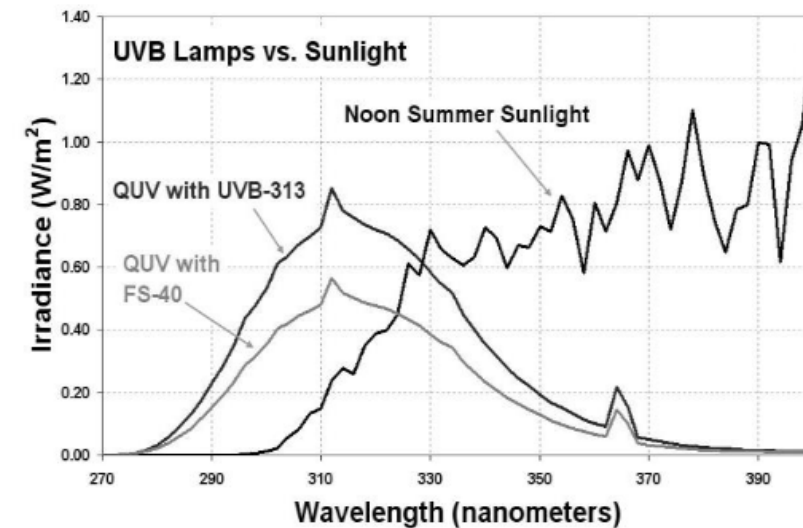
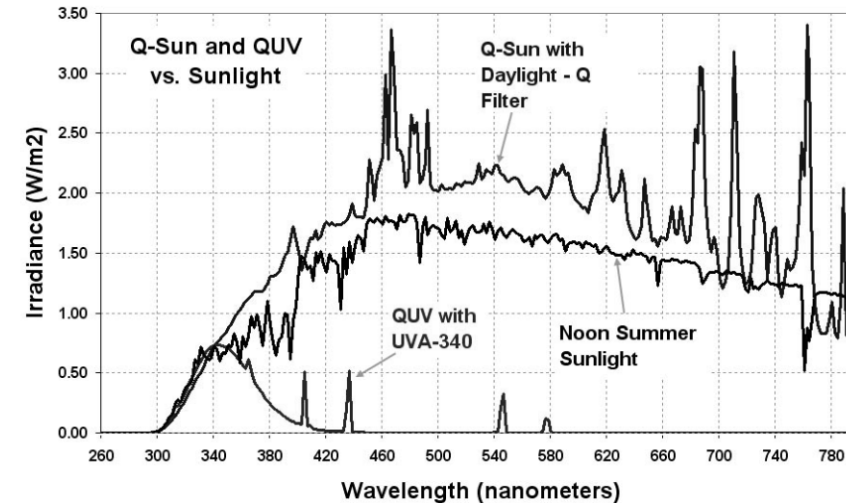
- Dimensionally stable types showed lowest Std. Dev
- Primed aluminum & cement board were most consistent



Sample	n	Mean	Std. Dev	Grouping		
SYP	162	3.1	2.0	A		
Primed Cedar	143	2.0	1.4		B	
Primed Hardie	107	1.8	1.1		B	C
Primed Galvanized	108	1.6	1.6		B	C
Primed Aluminum	108	1.4	1.1			C

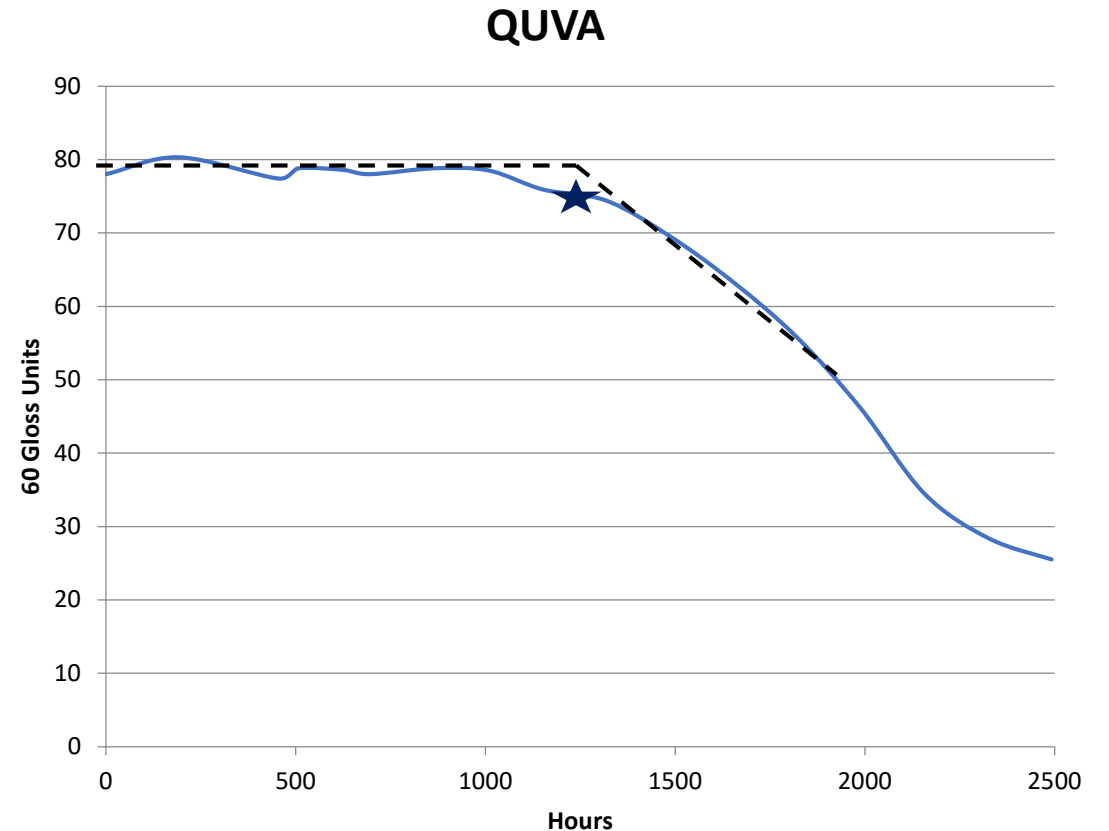
Accelerated Approaches

- **QUV-A (340nm)**
 - Industry Standard for coatings
 - 8hr UV, 4 condensation; 60/50°C
 - Mimics higher energy portion of solar radiation, 340nm
- **Xenon Arc (290-800)**
 - Stronger match for full range solar radiation
 - Less common than QUVA
- **QUV-B (313nm)**
 - Highest energy wavelength, 313nm
 - Typically only used for extremely durable materials



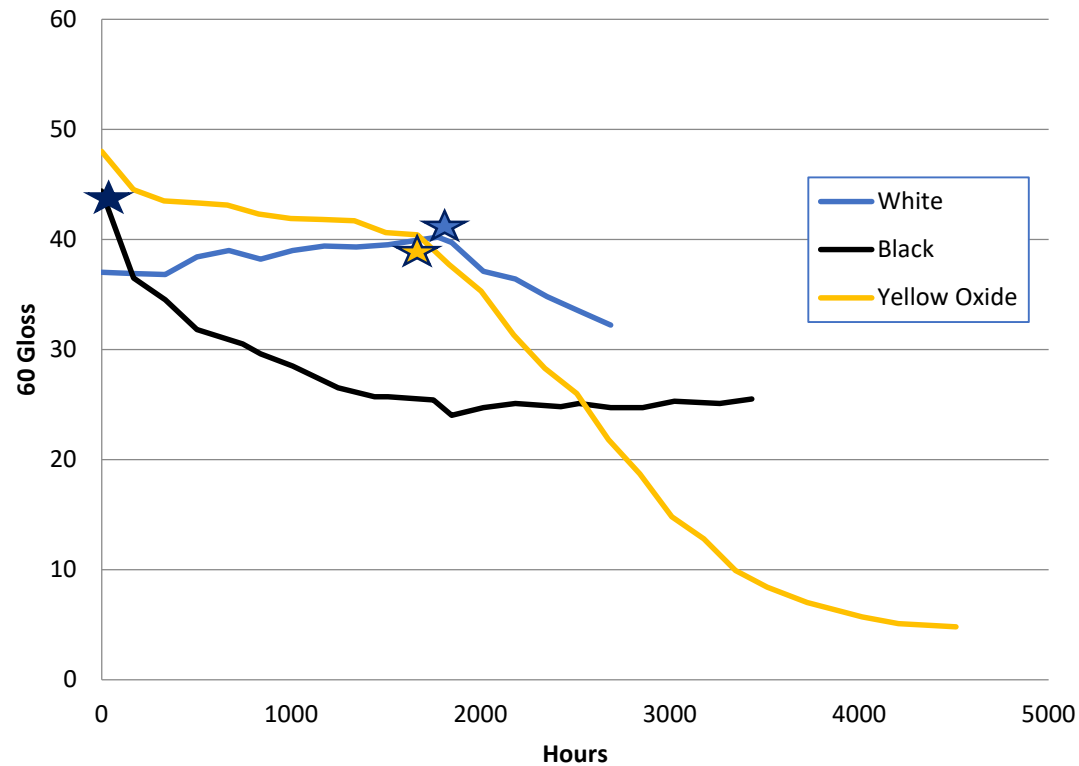
Onset of Gloss Loss in Cyclic Testing

- High performance architectural coatings tend to maintain constant gloss over a period of time
- After a exposure, sufficient UV induced degradation has occurred that film erosion and roughness is detectable by gloss measurement
- It is important to validate QUVA with true exterior weathering

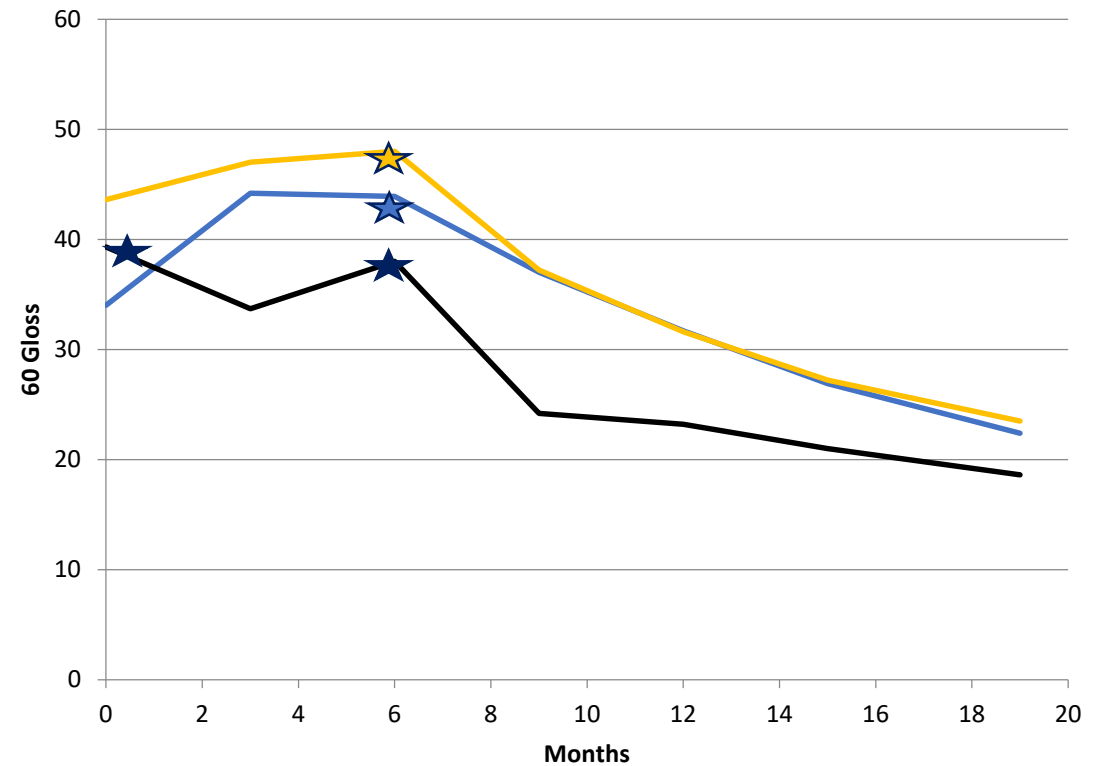


Relating QUV to Exterior Exposure

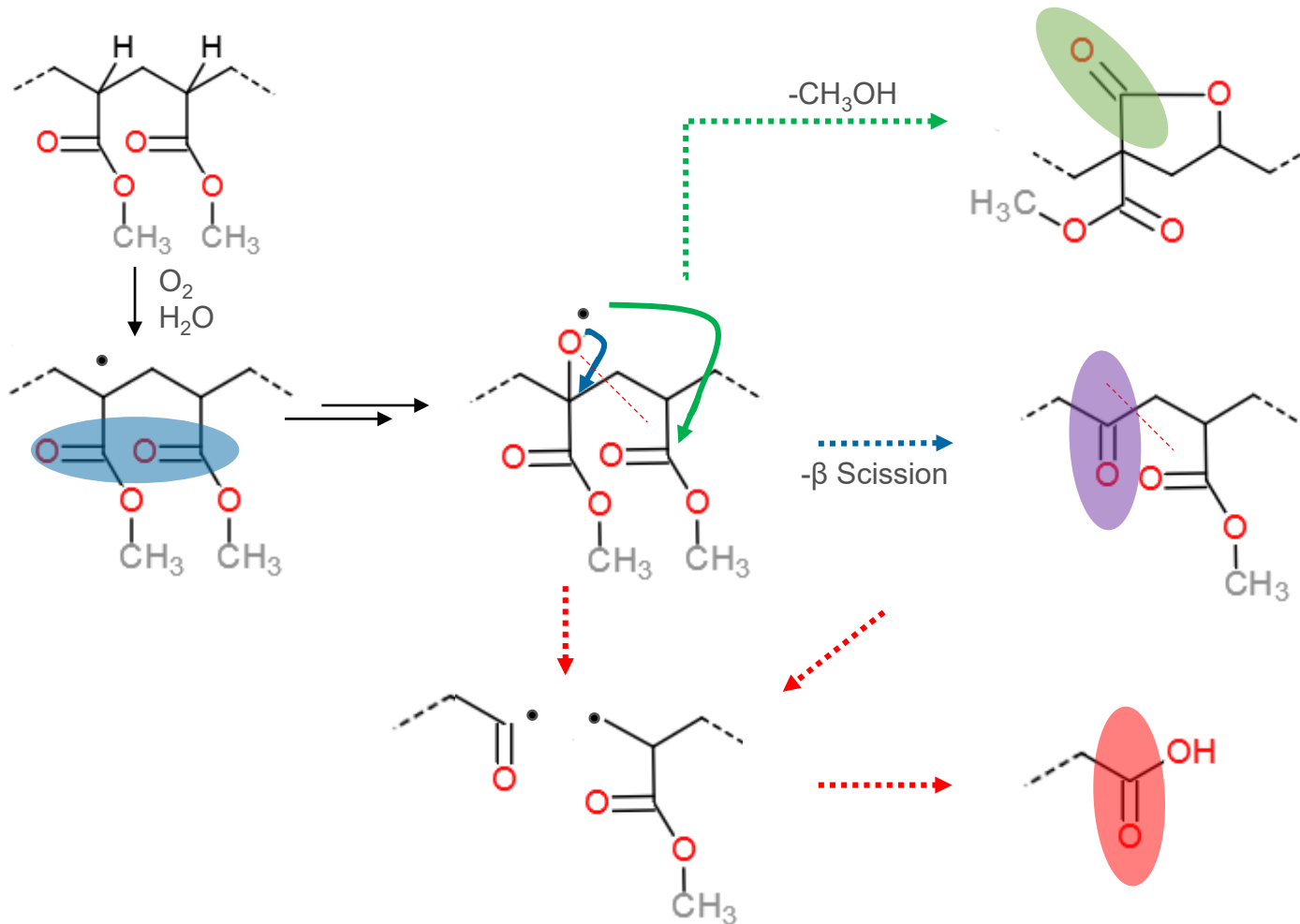
Cyclic QUVA



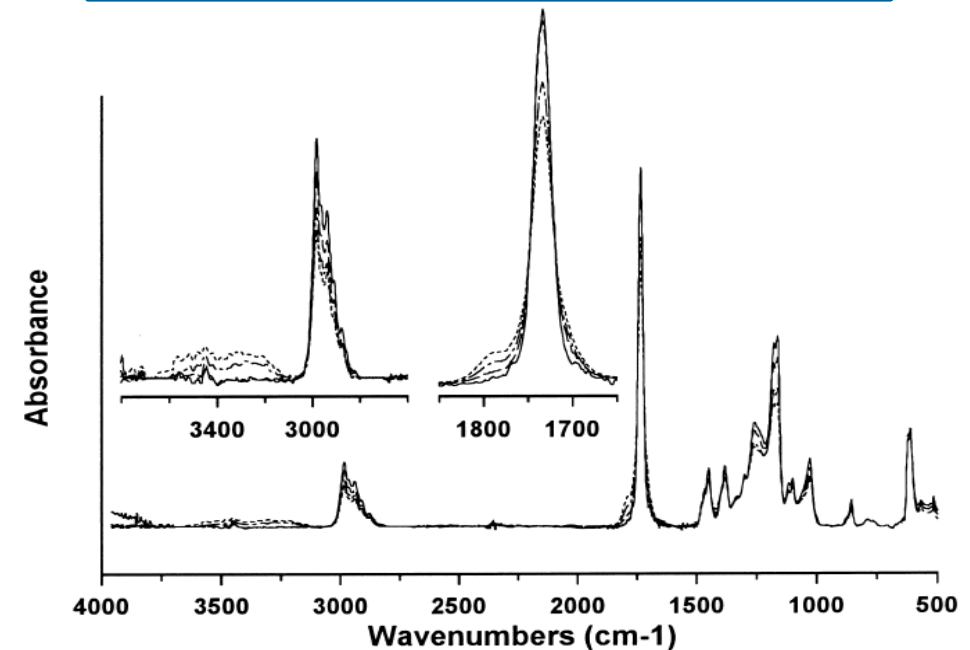
Florida Exposure – Primed Aluminum



Modes of UV-Degradation



- γ -Lactone** - 1780 cm^{-1}
- Ketone** - 1710 cm^{-1}
- Carboxy Acid** - 1705 cm^{-1}
- Ester** - 1735 cm^{-1}

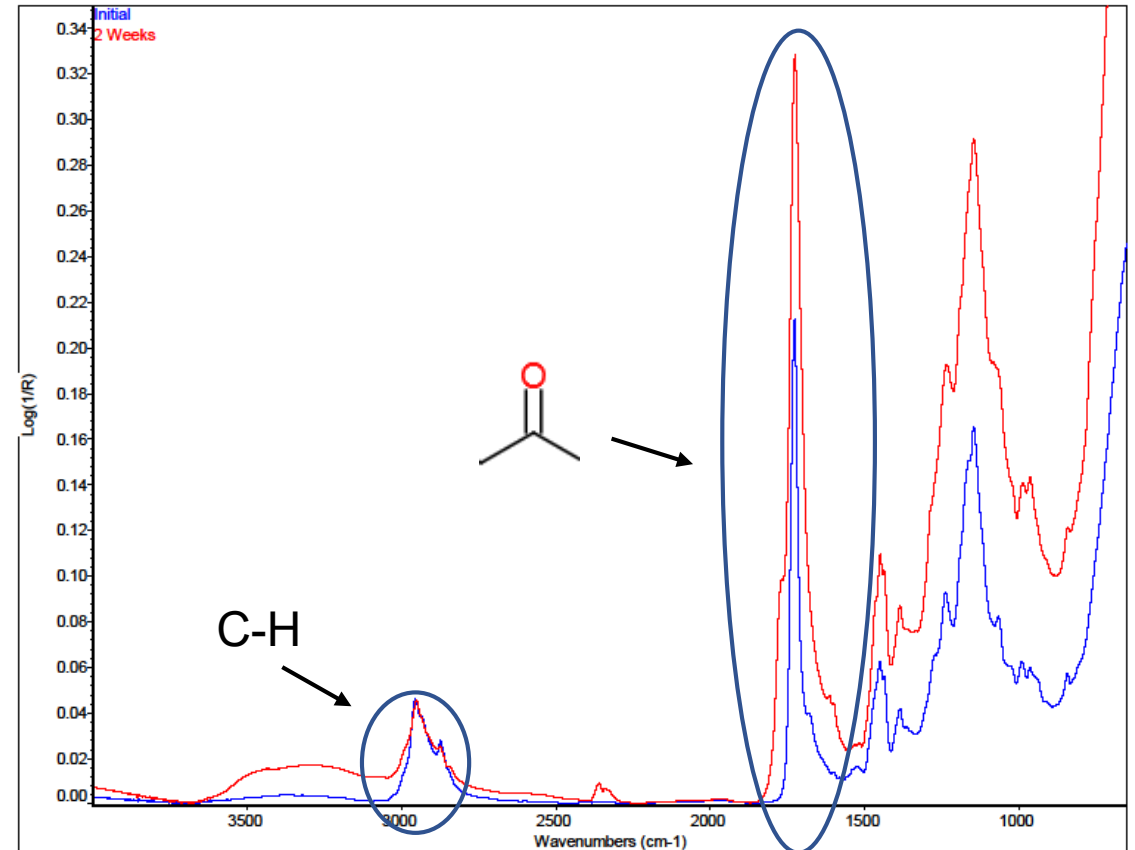


Functional Group Analysis

- ATR-FTIR allows semi-quantitative analysis of film degradation
- Relating C-H to C=O demonstrates trends in degradation

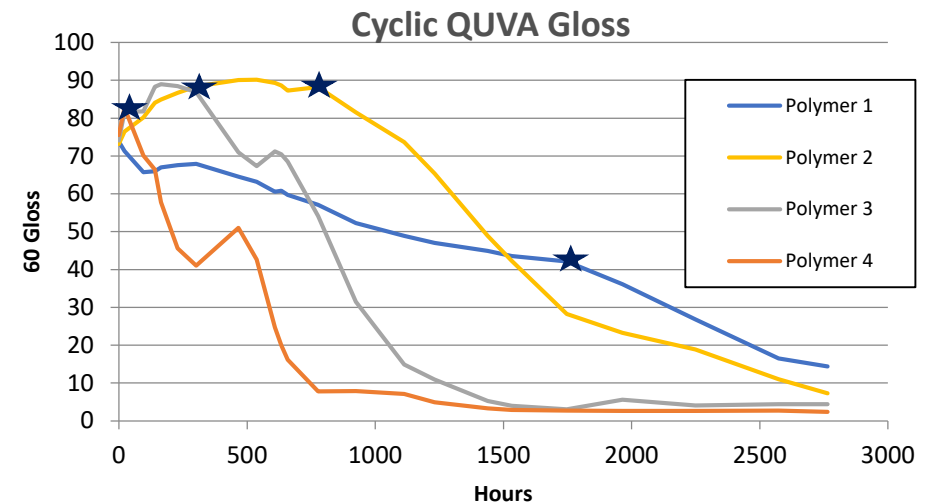
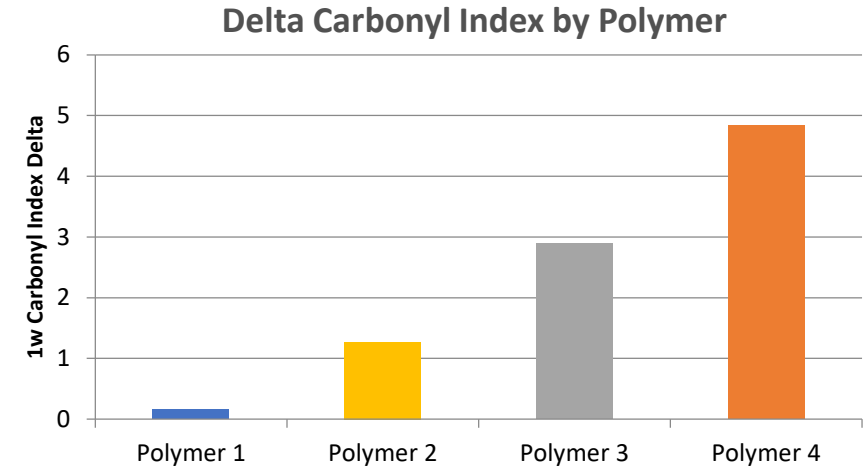
- $$\frac{\int 1600-1800\text{cm}^{-1}}{\int 2800-3050\text{cm}^{-1}} = \frac{\text{C=O}}{\text{C-H}} = \text{Carbonyl Index}$$

- **Comparing changes in index between samples predicts relative degradation rates**

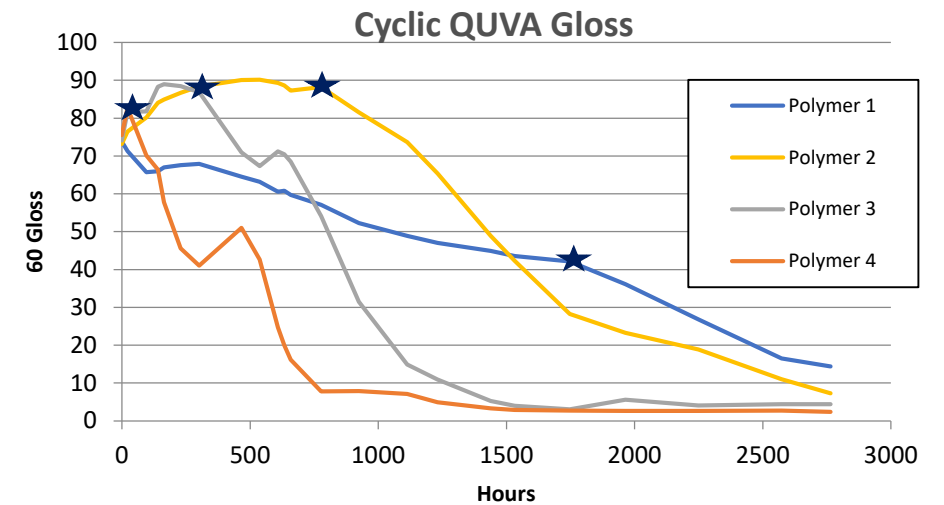
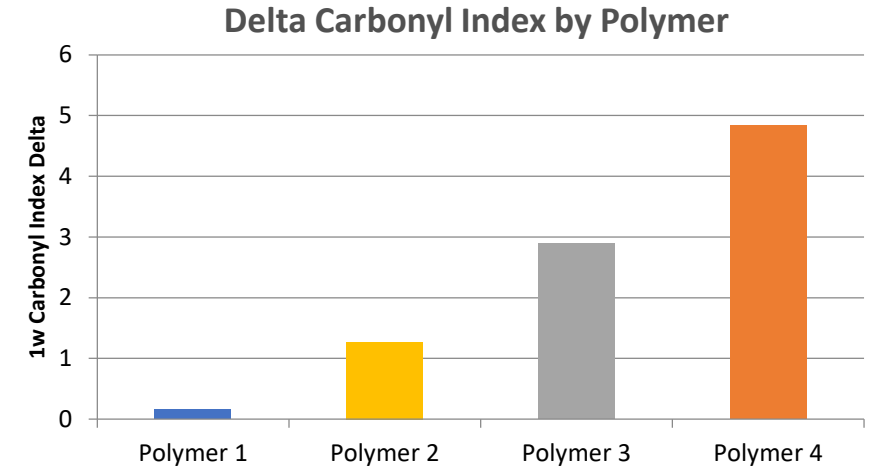
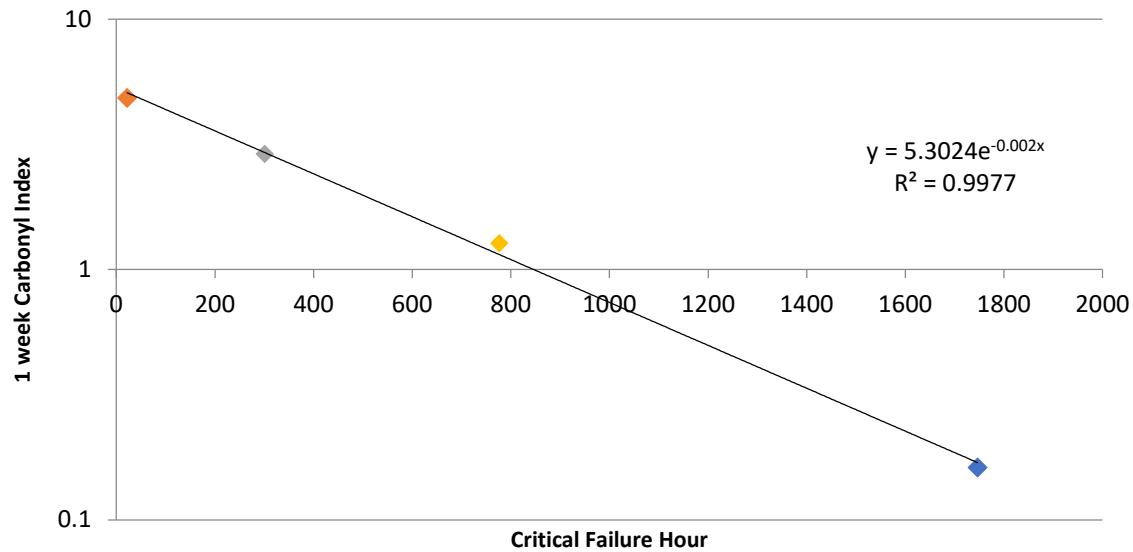


QUVA and Carbonyl Index

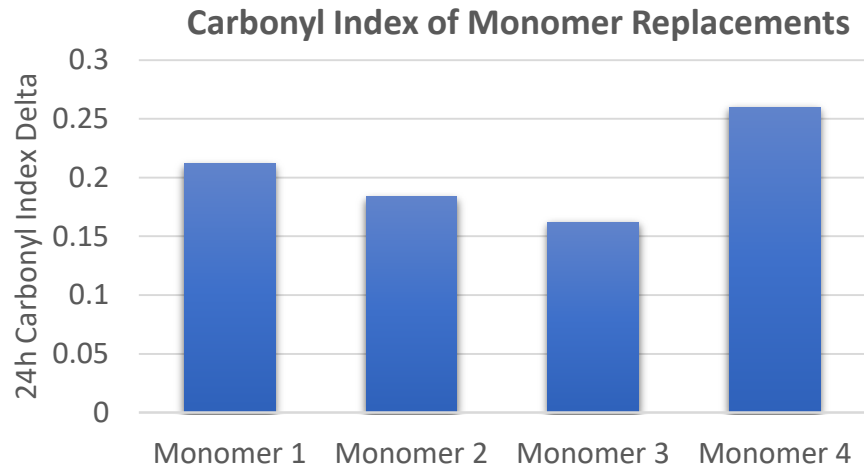
- Carbonyl index run on a polymer series at 0 and 7 days cyclic exposure
- The change in index predicts the relative rate of oxidative polymer degradation



QUVA and Carbonyl Index



Accelerating Development

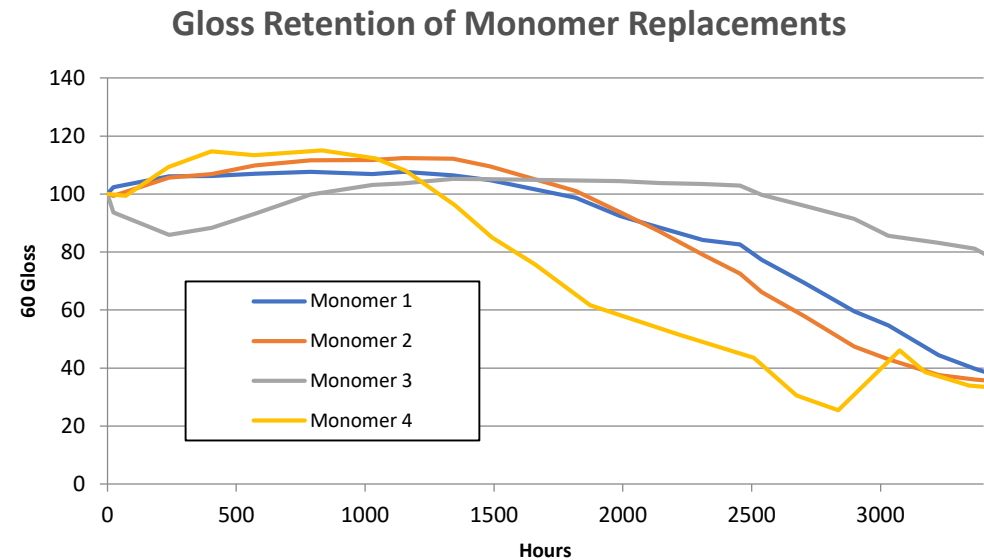


Results

- Carbonyl Index provides early indication of polymer performance
- Tight formulation control allows for strongest predictive power

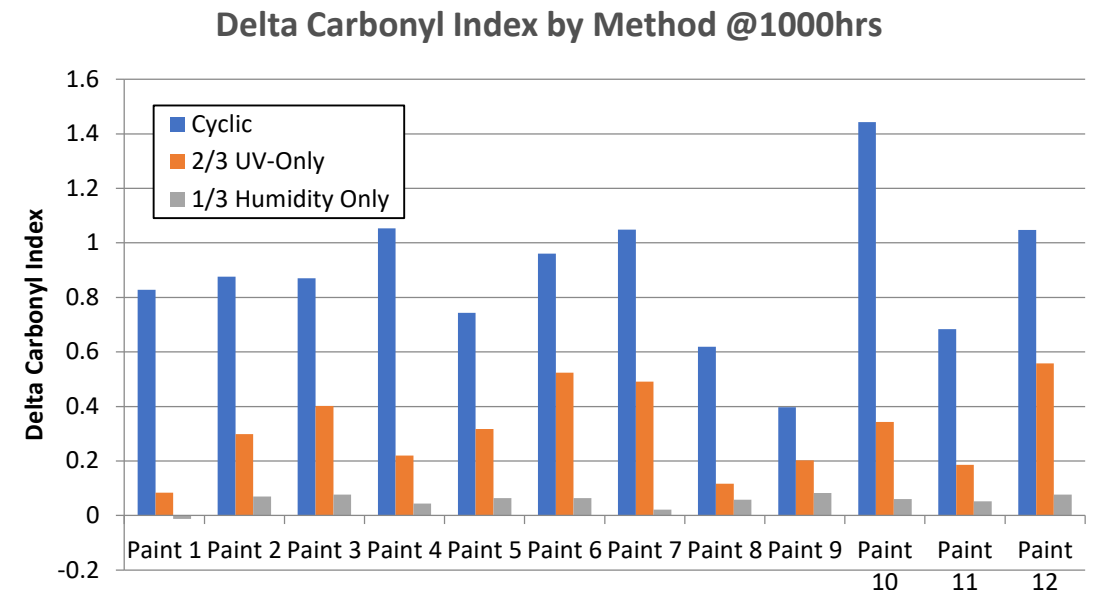
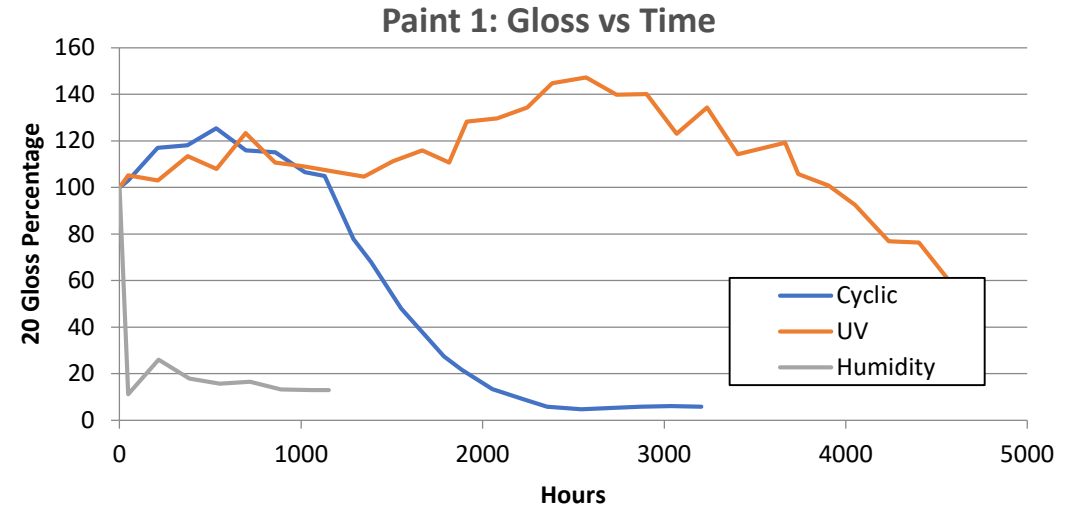
Experiment

- Replace primary monomer in polymer 1 with 3 alternatives, maintain Tg
- Expose to standard QUVA testing
- Evaluate carbonyl index at regular intervals



Cyclic QUVA vs. Alternative Exposures

- UV-only highlights the positive side of UV exposure, crosslinking, which can increase gloss
- Cyclic QUVA involves both a UV step and a humidity step, so it is valuable to determine their individual impacts
- The combination of UV and condensation provides a severe change in gloss behavior
- Humidity exposure (Cleveland) can also severely impact gloss, but carbonyl indexing is insensitive to this mode of failure



Summary

- Understanding the fundamentals of weathering is pivotal to developing innovative and differentiated technology
- ATR-FTIR allows for the characterization of UV degradation at a molecular level, and gives early predictions of polymer performance where carbonyl functionality is changing
- The study of separate UV or humidity cycles demonstrates that the presence of water has both a physical and chemical impact

Specials thanks to: Matt Andersson, Paige Booth, Chuck Myers, Jacob Bolton, Mike Wildman, Robert Sandoval, Gunnar Duner, Heidi Docktor



Thermo Fischer Nicolet iS10 with Smart iTR fixture

THANK YOU
QUESTIONS?

