The Effect of Florida and Accelerated Weathering Exposures on Photovoltaic Backsheets

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This presentation contains no confidential information
Introduction

- PV module’s return on investment is directly related to the module’s lifetime and performance.

- Photovoltaic power can only truly be considered “green” when modules can produce safe and reliable electricity for very long periods of time.

- Module makers should be able to select component materials of construction that have proven, long lasting performance.

- Current certification standards (UL and IEC) are focused on safety and short term output performance.
  - IEC 61215 UV preconditioning test: Preconditions modules – but does not measure durability. Total UV exposure (15 kWh/m² 280-385 nm) is less than 3 months direct exposure in Miami, FL.
  - A weathering durability test is needed for UL and IEC standards

- Long PV module lifetimes are supported by incorporating materials with proven, long term weatherability into the module.
Arkema initiated a study to examine effects of FL outdoor exposure on backsheets.

- Photo-degradation monitored by gloss retention, optical and SEM microscopy, chalking evaluation, and FTIR spectroscopy.
- Compare results with accelerated weathering using QUV A.

**Florida Outdoor Testing Conditions:**
- Samples located in Miami, FL.
- Samples oriented south facing at 45 degree angle facing the sun.

**QUV A - Accelerated Testing Conditions:**
- Irradiance of 1.55 at 340 nm, 8 hrs light at 60°C and 4 hrs dark at 50°C with condensation – (ASTM G154 Cycle 6).
- UV irradiance 295 – 385 nm = 85 W/m² or 4.91 MJ/m² in 24 hrs.
- Backsheets are facing the lamp.
- 1300 hrs exposure has equivalent UV radiation to 12 months direct exposure in Florida.
- In the Field - Backsheet exposure is a percentage of direct exposure (25% - 10%).

**Backsheet Materials Tested:**
- KPE® Backsheet – Kynar® Film/ PET /EVA backsheet
- Other fluoropolymer film based backsheets
- Non-fluoropolymer based backsheets
1300 hrs. QUV A exposure has equivalent UV radiation to 1 year direct exposure in FL.

The decreasing gloss retention trends observed in realtime Florida exposure are the same as observed after QUV A accelerated weathering exposure just at slower rates due to the decreased amount of UV radiation.

We expect Florida exposure results to continue following the trend seen in accelerated QUV A results.
SEM Images of KPE® Backsheet

Florida Exposure:
- Year 1, no degradation or cracking of backsheet occurring.
- Year 2, no degradation or cracking of backsheet occurring.
- Year 3, still no degradation or cracking of backsheet occurring.

QUV A Exposure:
- 1000 hrs, no degradation or cracking of backsheet occurring.
- 3000 hrs, no degradation or cracking of backsheet occurring.
- 5000 hrs, still no degradation or cracking of backsheet occurring.
Florida Exposure:
- Year 1, top layer of backsheet is cracking.
- Year 2, outer layer of backsheet is falling off and middle layer is beginning to crack.
- Year 3, middle layer is cracking.

QUV A Exposure:
- 1000 hrs, polymer matrix is degrading leaving pigment particles on the surface.
- 3000 hrs, pigment particles cover the surface.
- 5000 hrs, some of the pigment particles have fallen off the surface revealing that the backsheet is cracking.
Florida Exposure:
- Year 1, small cracks are appearing and polymer matrix is degrading.
- Year 2, more cracks are forming as the backsheet continues to degrade.
- Year 3, degradation of the polymer matrix is continuing.

QUV A Exposure:
- 1000 hrs, backsheet is beginning to crack; polymer matrix is degrading.
- 3000 hrs, polymer degradation has progressed - pigment particles cover the surface.
- 5000 hrs, pigment particles have fallen off the surface revealing that the backsheet is cracking.
**Florida Exposure:**
- Year 1, little to no degradation is occurring.
- Year 2, degradation of the polymer matrix is starting around the pigment particles.
- Year 3, degradation is continuing.

**QUV A Exposure:**
- 5000 hrs, polymer matrix is beginning to degrade around the pigment particles.
Conclusions

- Gloss retention in Florida exposure correlates well with gloss retention in accelerated QUV A testing.

- Similar backsheet degradation mechanisms (cracking and polymer degradation) are observed in Florida and QUV A exposures.

- Kynar® film protected backsheets show no signs of polymer degradation or cracking after 3 years of Florida exposure.

- Short term Florida and QUV A exposures show significant degradation of Non-Fluoropolymer based backsheets.
  - Non-Fluoropolymer, Type 1 backsheet shows cracking after only 1 year FL exposure. After 3 years, cracking has progressed into the middle layer.
  - Accelerated QUV A testing of Non-Fluoropolymer, Type 1 shows cracks only after long exposure, but maybe masked by pigment accumulation.
  - Non-Fluoropolymer, Type 2 backsheet shows microcracks and surface erosion in only 1 year of FL exposure. After 3 years, surface erosion is becoming more significant.
  - Accelerated QUV A testing of Non-Fluoropolymer, Type 2 shows larger cracks vs. Florida exposure after 1000 hrs.
  - Both Non-Fluoropolymer backsheets show rapid gloss loss.

- Other Fluoropolymer Film based backsheets lose gloss with Florida and QUV A exposure.
  - After 2 years of Florida exposure, the polymer matrix of Other Fluoropolymer, Type 1 backsheet is starting to degrade.

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Accelerated Weathering Test Improvements

Better UV Exposure test (than IEC) is needed to test products for durability over 25+ year product lifetime

- 5000 hrs QUV A at 1.55 Irrad. approximately equals 25 years in FL at 15% of direct irradiance.

Differences between weathering study exposures and use in PV modules

- In PV modules, backsheets have more thermal cycle/shock and mechanical stress because of laminated structure and heat build.
- QUV has no thermal cycle/shock.
- Florida backsheet exposure lacks applied stress.

Concern:

- Current backsheet study shows crack development in both Florida and QUV A exposures.
- Lack of thermal cycle and mechanical stress limits the ability to test propensity for crack propagation.

Proposal for Improvement in Accelerated Testing

- Add thermal shock/cycle to testing protocol by using multiple water spray – light cycles.
  - Goal is to add many thermal cycles and stress to accelerate this phenomena.