Weathering Performance of PV Backsheets

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ARKEMA
INNOVATIVE CHEMISTRY

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.

- **Long PV module lifetimes are supported by using materials with proven, long term weatherability.**
  - A weathering durability test is needed for UL and IEC standards

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Weathering Study Details

- **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.
  - Direct Exposure samples oriented south facing at 45 degrees angle facing the sun.
  - Indirect Exposure samples oriented north facing at 45 degree angle facing the ground.
- **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 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
  - PVF, Gen 1 - PVF Generation 1/PET/PVF Generation 1 backsheet
  - PVF, Gen 2 - PVF Generation 2/PET/PVF Generation 2 backsheet
  - FPE - Partially fluorinated coating based backsheet
  - PPE - Weatherable polyester backsheet
  - AAA - Polyamide based backsheet

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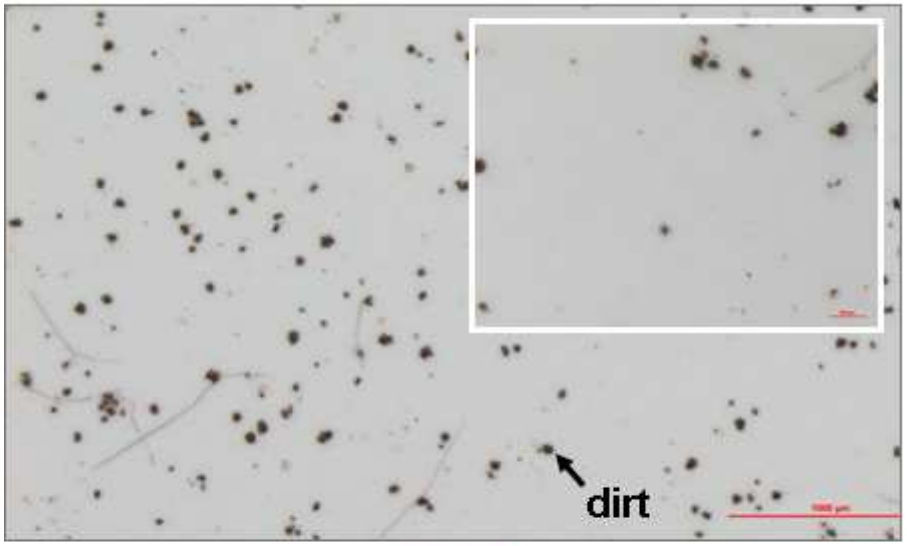
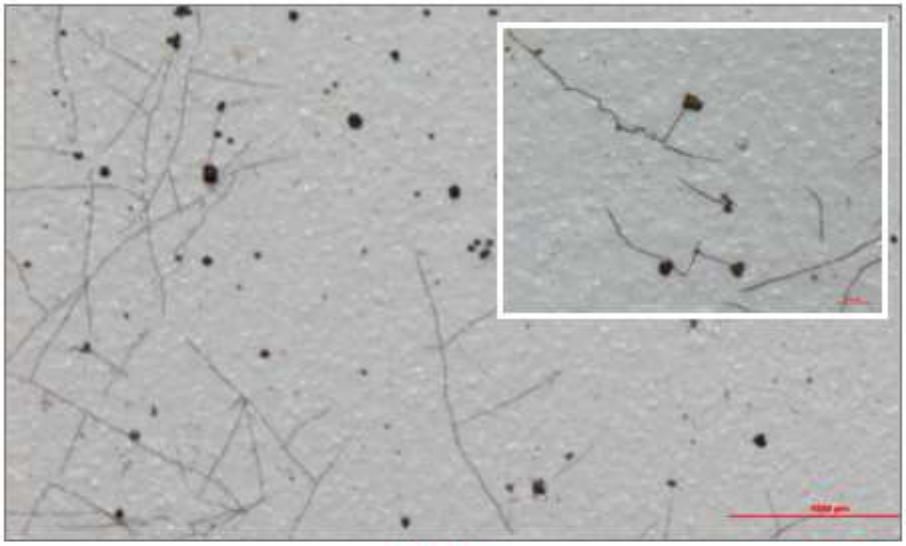
Optical Images after 2 yr. FL Direct Exposure

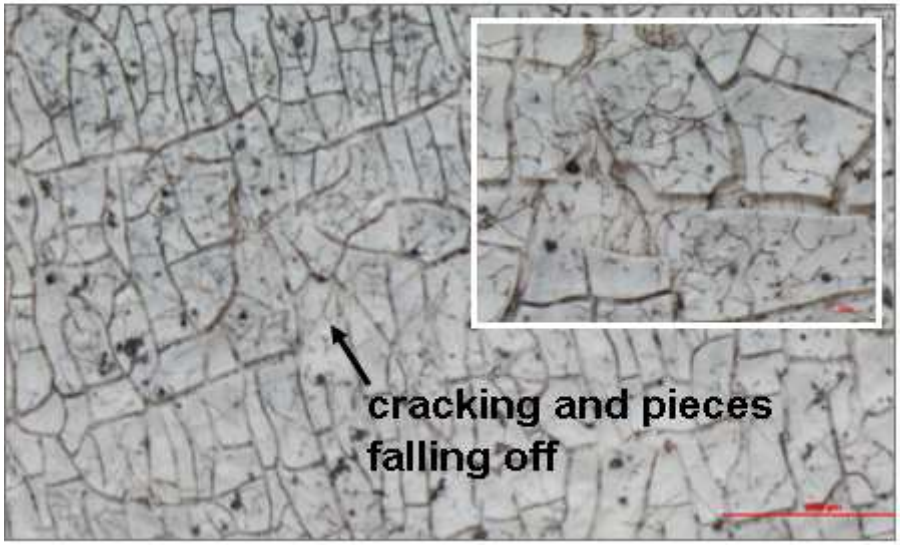
KPE ® Backsheet



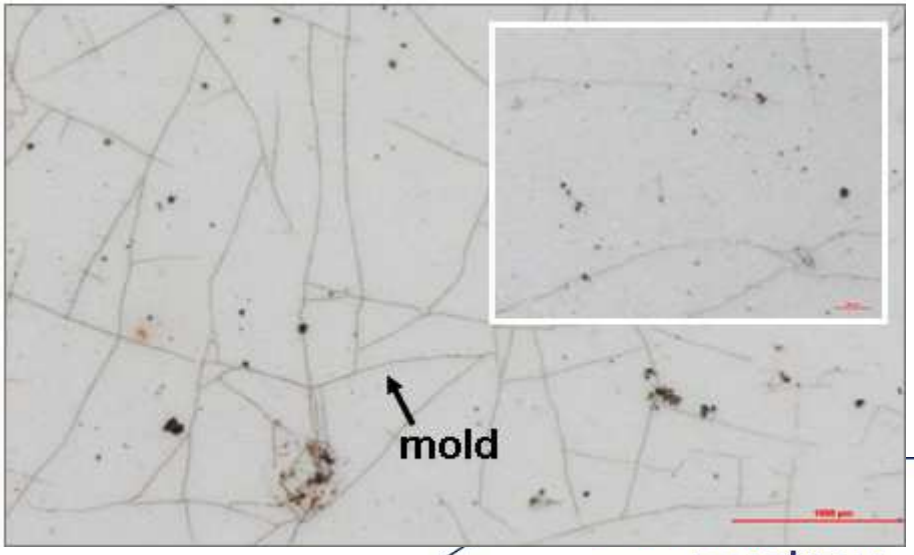
PVF, Gen 1



AAA



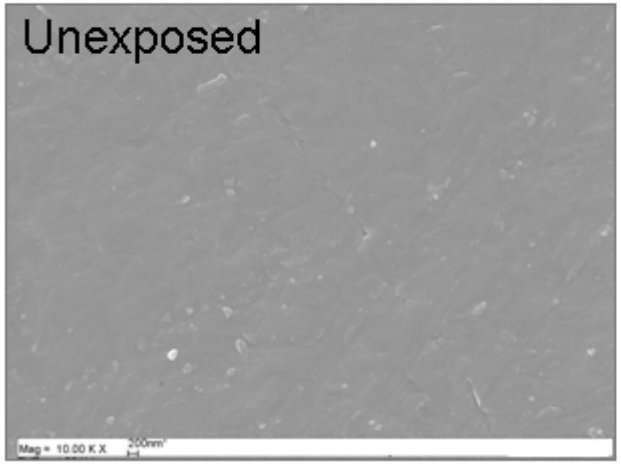
PPE

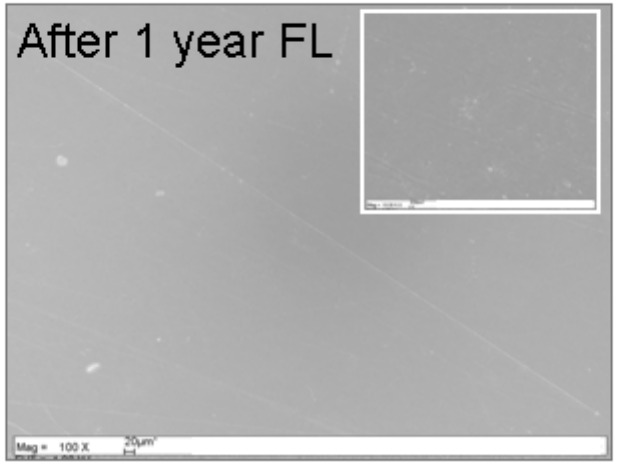


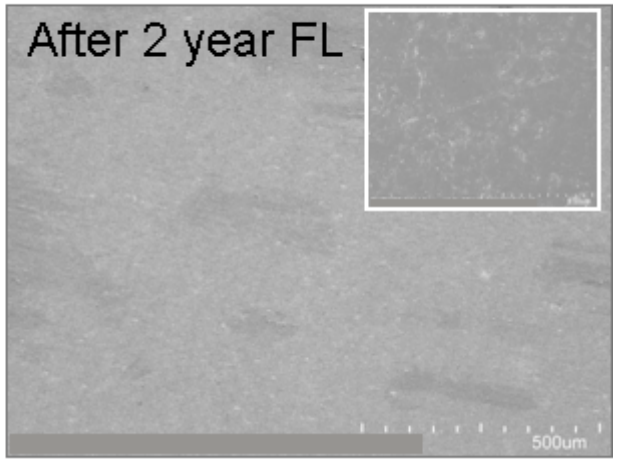
Images obtained on unwashed samples: show dirt specks, mold growth, and cracking.

SEM Images of Unexposed and Florida Direct Exposure

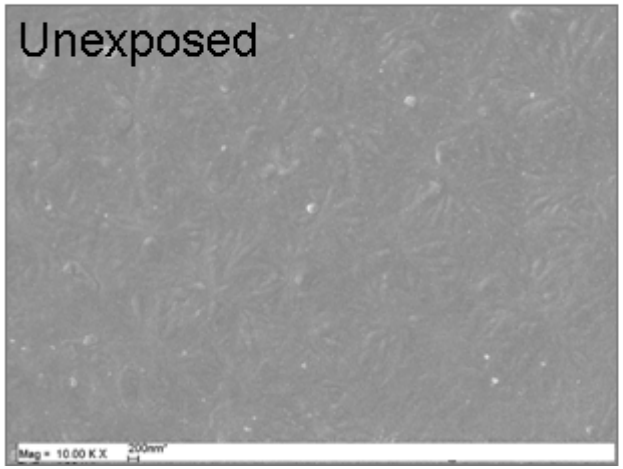
KPE® Backsheet

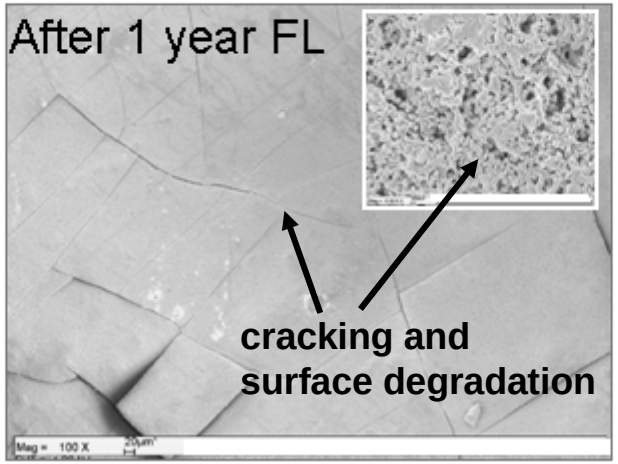


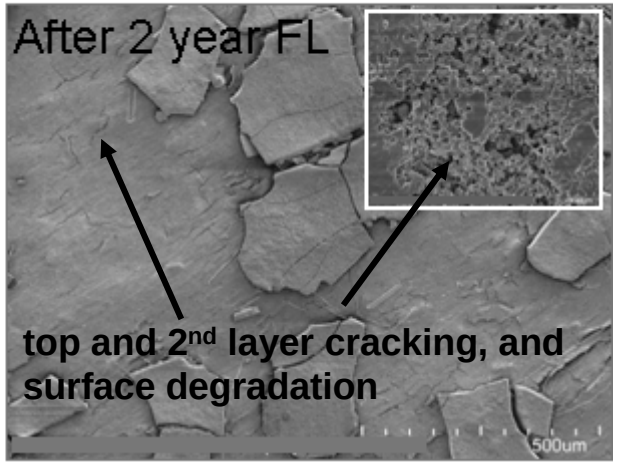




AAA







•Samples washed prior to imaging. AAA lost a significant amount of its top layer when the sample was rinsed gently with DI water. KPE® Backsheet shows no chalking.

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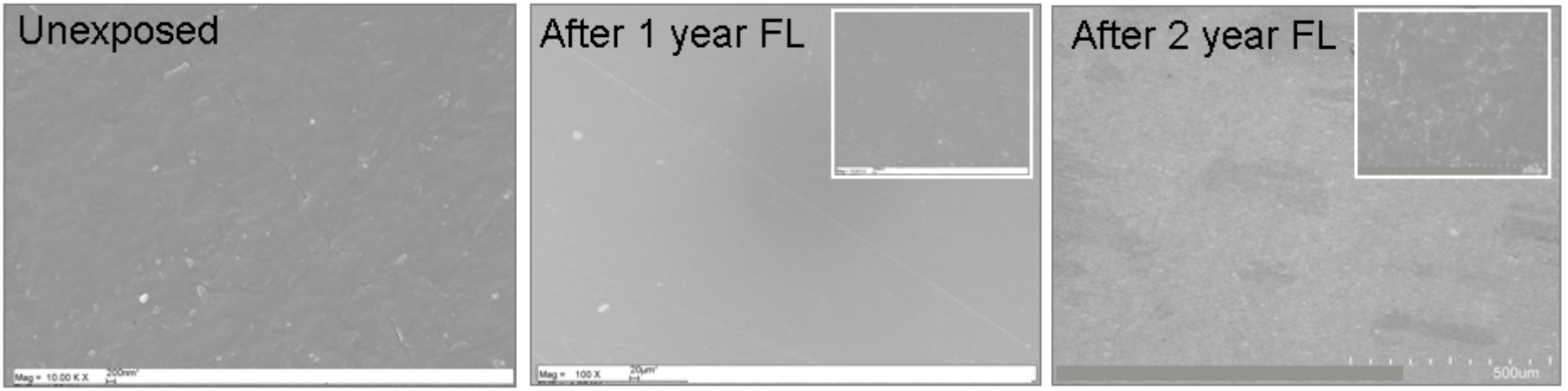
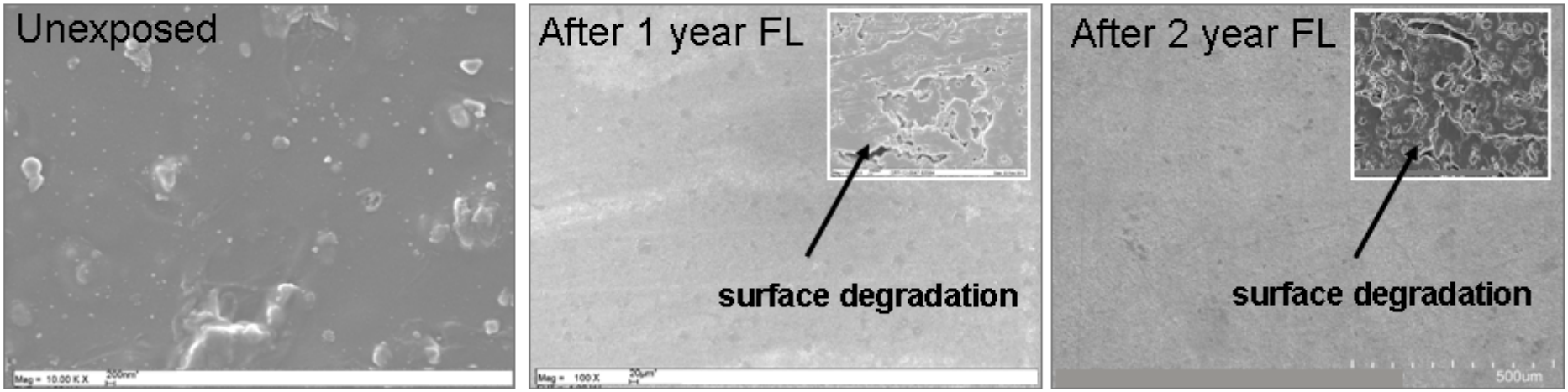
SEM Images of Unexposed and Florida Direct Exposure

KPE® Backsheet



PPE



•Samples washed prior to imaging.

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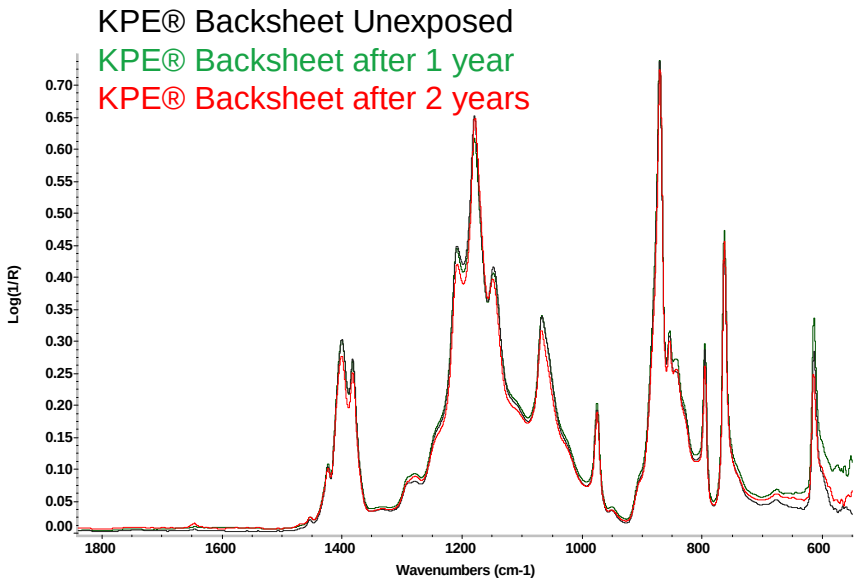
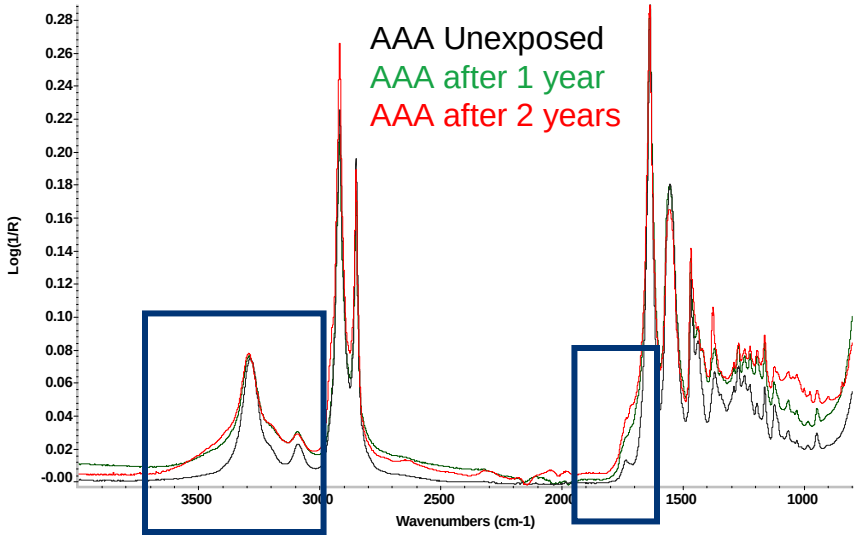
FTIR Spectra of Backsheets after Direct FL Exposure



- No spectral changes KPE® Backsheet surface.
- No sign of degradation.



- AAA shows significant degradation by oxidation of polymer.
- NH/OH and –C=O spectral regions indicates increasing OH.

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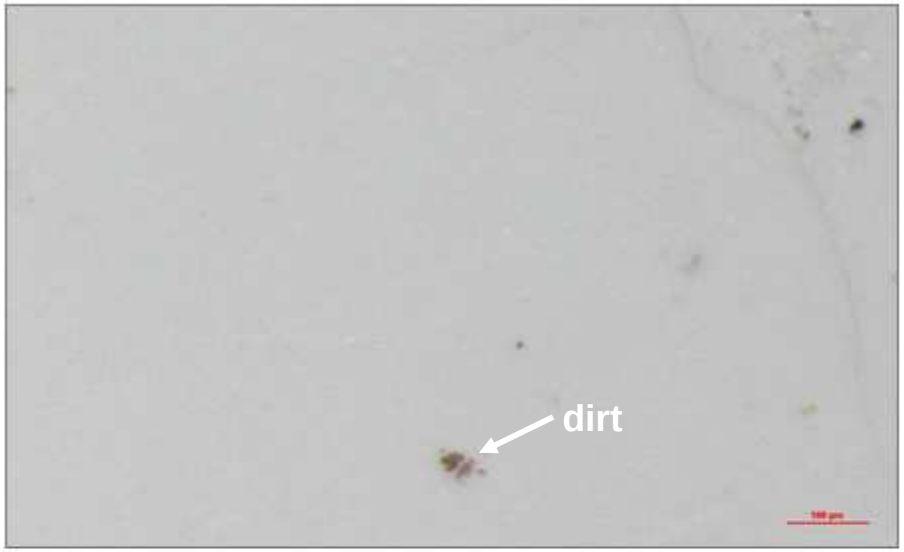
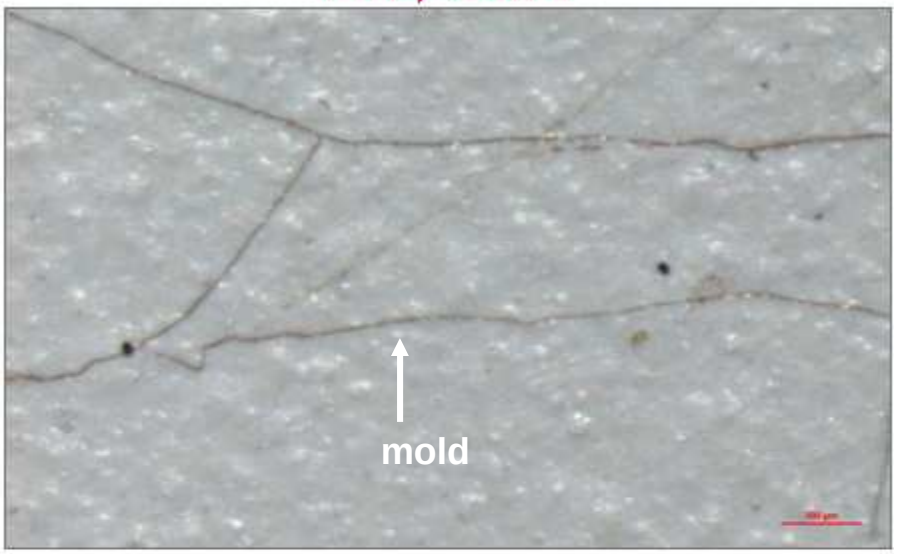
Optical Images after 2 yr. Florida Indirect Exposure

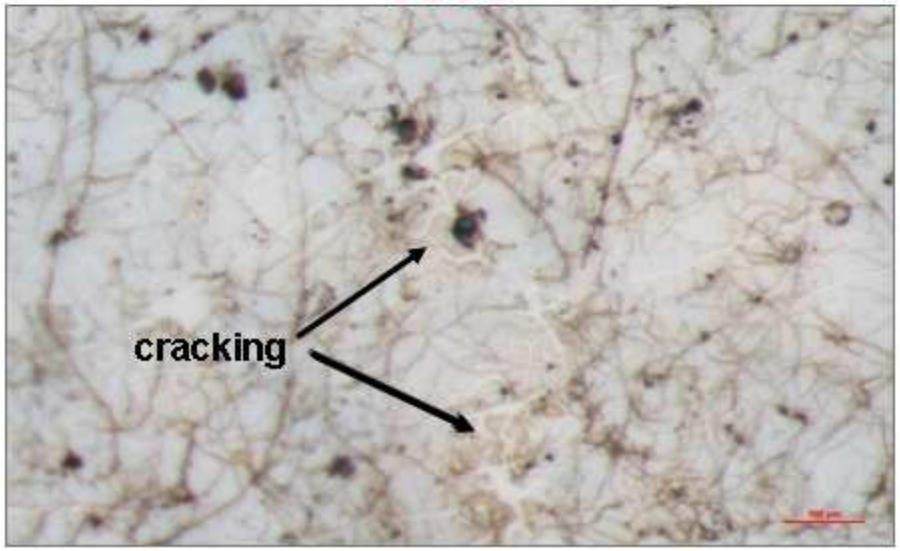
KPE® Backsheet

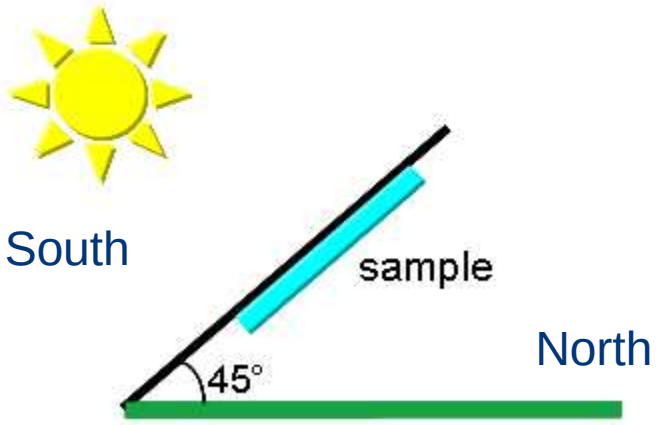


PVF, Gen 1



AAA





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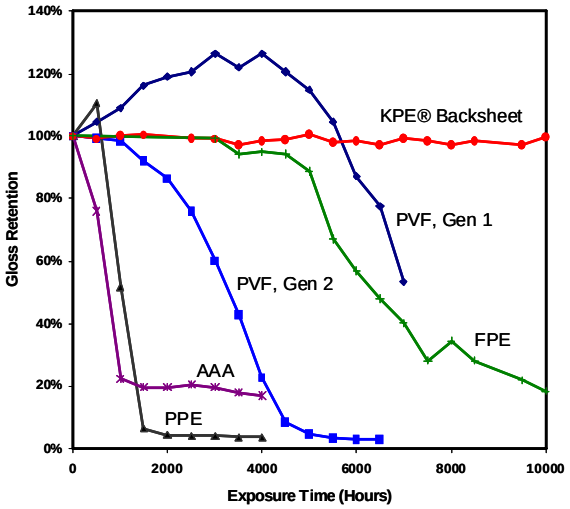
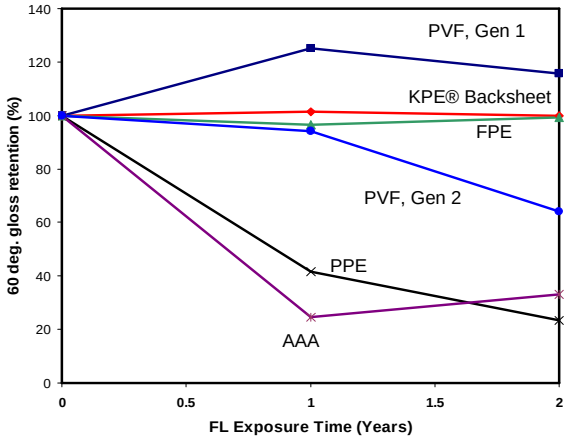
Surface Degradation of Backsheets

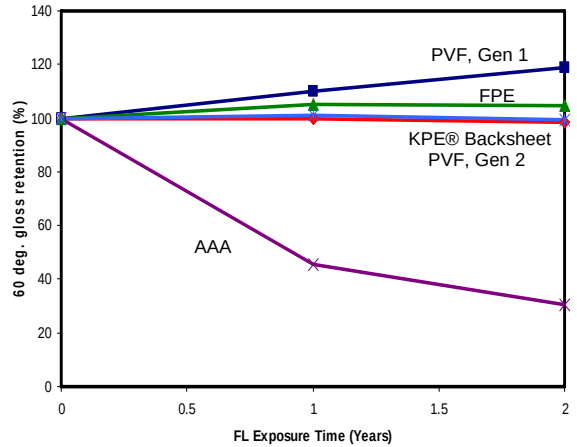
QUVA Accelerated Weathering



Florida - Direct Exposure



Florida - Indirect Exposure



- 1300 hrs. QUV A exposure has equivalent UV radiation to 1 year direct exposure in FL.
- Indirect exposure, typical for backsheets, is a percentage of direct exposure.
- The same decreasing gloss retention trends observed in QUV A are being measured in both direct and indirect FL exposures just at slower rates due to decreased amount of UV radiation.
- In a few years, we expect the plots of gloss retention versus exposure time for the three different types of exposures to look the same.

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Conclusions

- **Short term outdoor exposure shows significant UV degradation of both AAA and PPE backsheets (after only 1 year of FL exposure).**
- **Fluoropolymer based backsheets show little to no change after 2 years FL exposure.**
- **AAA backsheet shows surface cracking and mold growth after only 1 year FL exposure. PPE shows surface erosion and gloss loss in only 1 year of FL exposure. After 2 years the AAA has cracks through the outside layer.**
- **Gloss retention in outdoor tests correlates well with gloss retention in accelerated QUV A testing protocol. Both show rapid gloss loss for both AAA and PPE backsheets.**
- **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.

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