

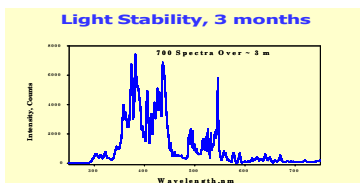
INTRODUCTION

Linking accelerated laboratory test results to field performance and predicting service life for polymeric materials are being investigated at the National Institute of Standards and Technology (NIST). In 2007, we successfully linked the laboratory and field exposure data for a model polymeric coating material, i.e., an amine-cured epoxy, using the **reliability-based methodology**.

Currently, we apply the same methodology to the polymeric materials used in PV modules and systems. The laboratory accelerated tests of PV polymers (frontsheet, backsheet, encapsulants, etc) were conducted on the well-controlled NIST SPHERE environmental chamber using a 4-factorial experimental design. The outdoor exposure was carried out in Gaithersburg, MD. Multiscale chemical, optical, mechanical and morphological measurements were carried out to follow changes during accelerated and outdoor exposures. The degradation mechanism and failure mode of PV materials and components were studied. Models for linking laboratory and outdoor results and predicting service life of PV materials are being developed.

ACCELERATED LABORATORY EXPOSURE DEVICE

NIST Integrating Sphere-based UV Chamber



- 8400 W UV → 22 "SUNS"
- 95% exposure uniformity
- Visible and infrared radiation mostly removed
- Temperature and relative humidity around specimens precisely controlled (25-75 °C ± 0.1°C; 0-95 % ± 0.2 % RH)
- Capability for mechanical loading
- Exposure conditions of 32 chambers can be individually controlled (UV, RH, T)

NIST-Patented 2-meter SPHERE

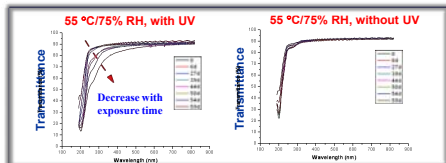
(Simulated Photodegradation via High Energy Radiant Exposure)

* Chin et al, Review of Scientific Instruments (2004), 75, 4951; Martin and Chin, U.S. Patent 6626053

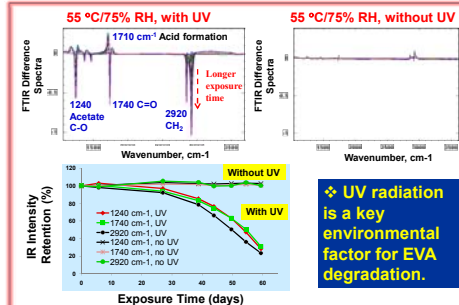
RESULTS FROM LABORATORY EXPOSURE

Effect of UV Irradiation on Degradation of EVA

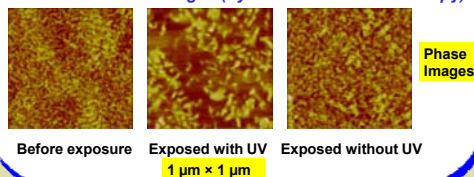
Optical Property Changes (by UV-visible Spectroscopy)



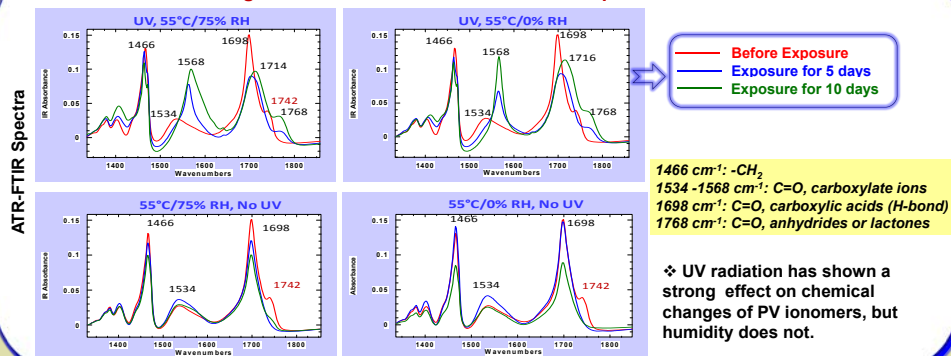
Chemical Changes (by FTIR Spectroscopy)



Nanostructural Changes (by Atomic Force Microscopy)

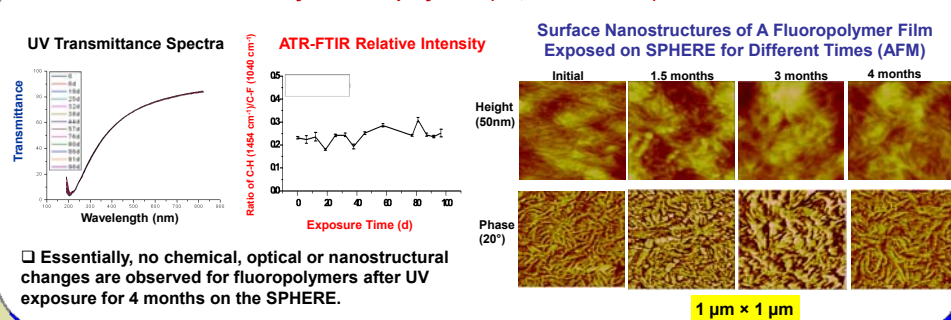


Chemical Changes of PV Ionomers Under Different Exposure Conditions



❖ UV radiation has shown a strong effect on chemical changes of PV ionomers, but humidity does not.

Photostability of Fluoropolymers (UV, 55 °C/75%RH)



❑ Essentially, no chemical, optical or nanostructural changes are observed for fluoropolymers after UV exposure for 4 months on the SPHERE.

SUMMARY AND FUTURE WORK

- NIST SPHERE is a highly efficient UV weathering device for both rapid screening and fundamental study of reliability of PV materials and components.
- ❑ The SPHERE exposure results will be quantitatively correlated with outdoor data using mathematical predictive models and reliability-based methodology.

Reliability-based Methodology for Linking Laboratory and Outdoor Exposure Results

