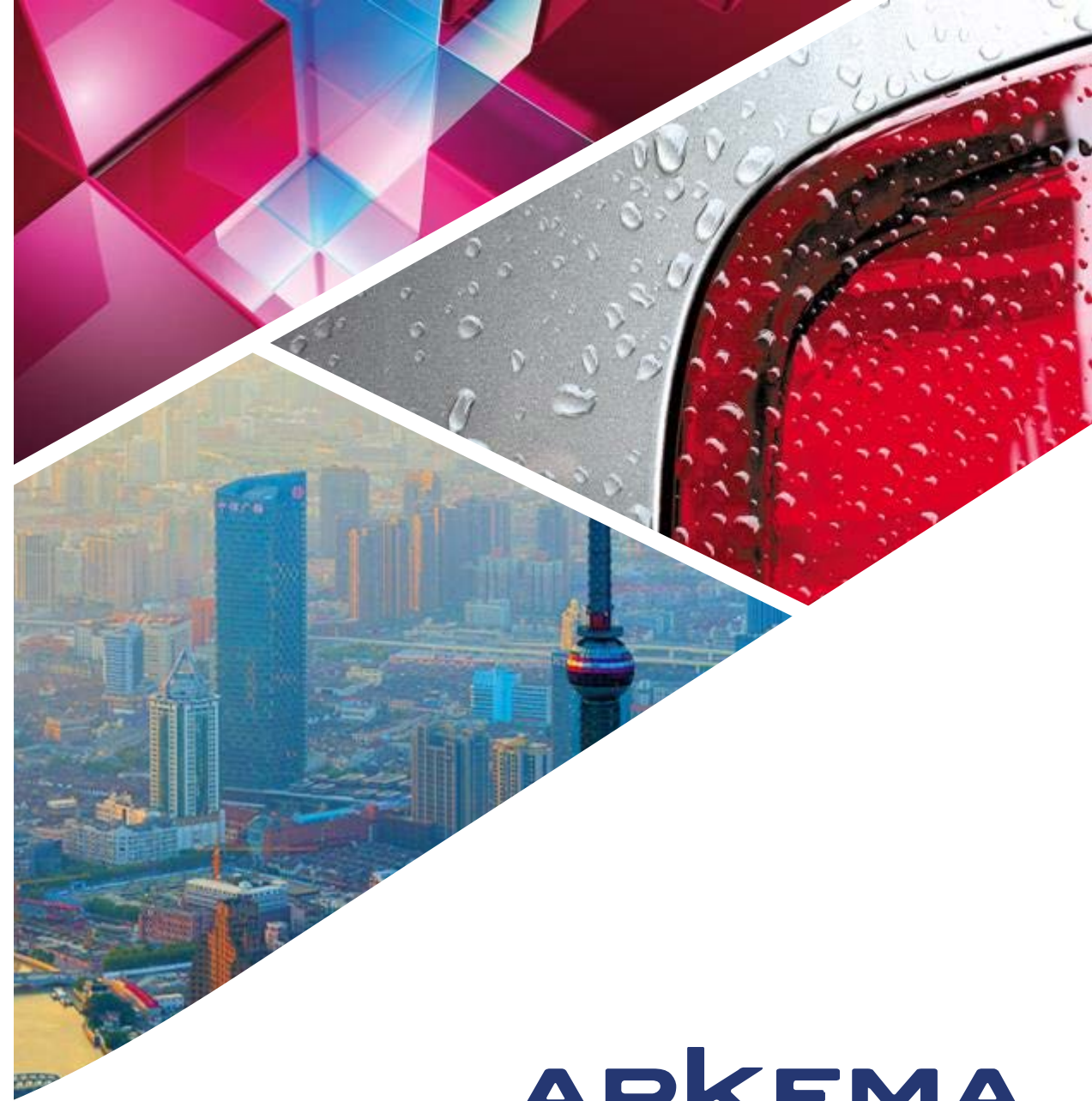


WEATHERING OF KYNAR® FLUOROPOLYMERS

FIVE YEAR SOUTH FLORIDA & XENON
ARC ACCELERATED WEATHERING

LEADING TO A NEW CHOICE
IN CABLE TIES

Gregory O'Brien
Amy Lefebvre
Bryan Douglas
NREL 2017



ARKEMA
INNOVATIVE CHEMISTRY

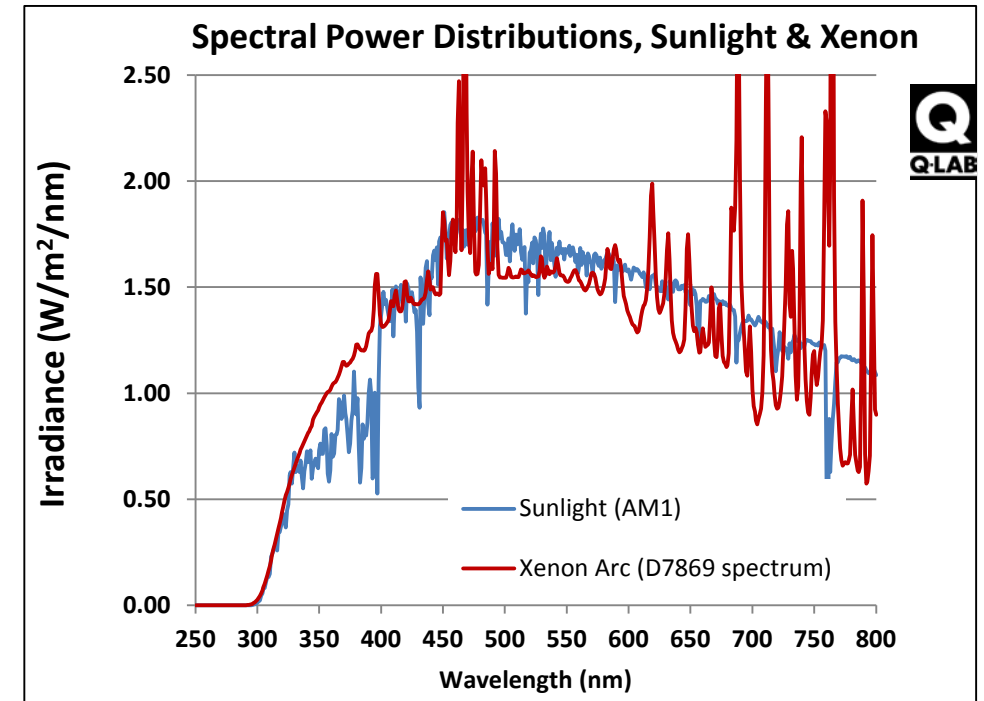
SUMMARY OF THE WORK WEATHERING STUDY PERFORMED

❖ 5 year southern Florida exposure

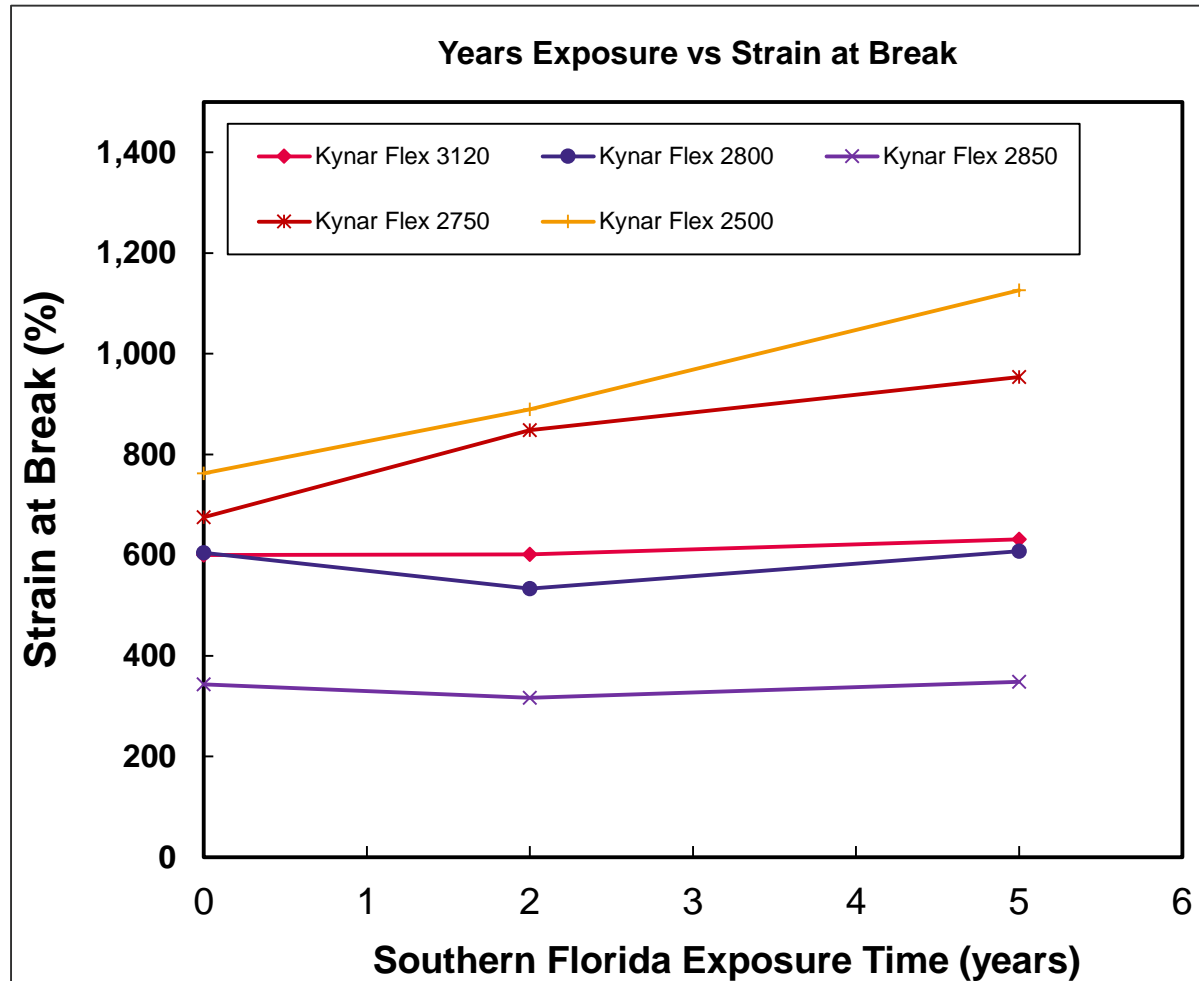
- Extruded Film Samples
- South facing
- 45 degree angle
- Optical testing yearly
- Mechanical Testing at 2 years and 5 years
- Exposures are continuing

❖ Xenon arc accelerated weathering

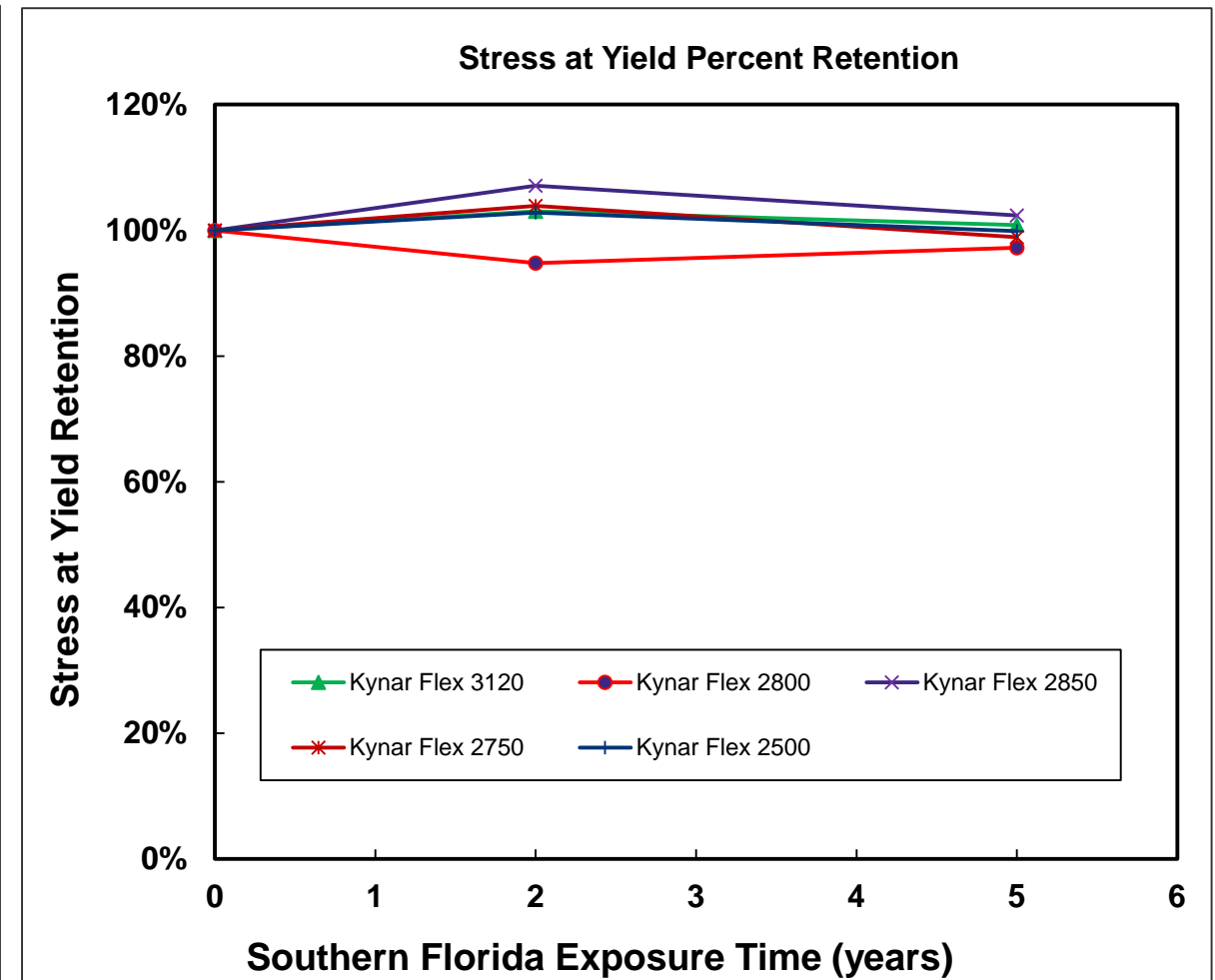
- Injection molded tensile bars
- Irradiance at 340 nm of 0.8 W/m²/nm
- Chamber Temperature of 70 °C
- Black Panel Temperature of 95 °C
- Cycle: 102 min light, then 18 min light plus water spray
- Samples tested optically and mechanically at 3000 & 5000 hr



MECHANICAL PROPERTY RETENTION – KYNAR® FILMS – 5 YRS IN FLORIDA



Five years in S. Florida – total UV exposure calculated at 1600 MJ/m²

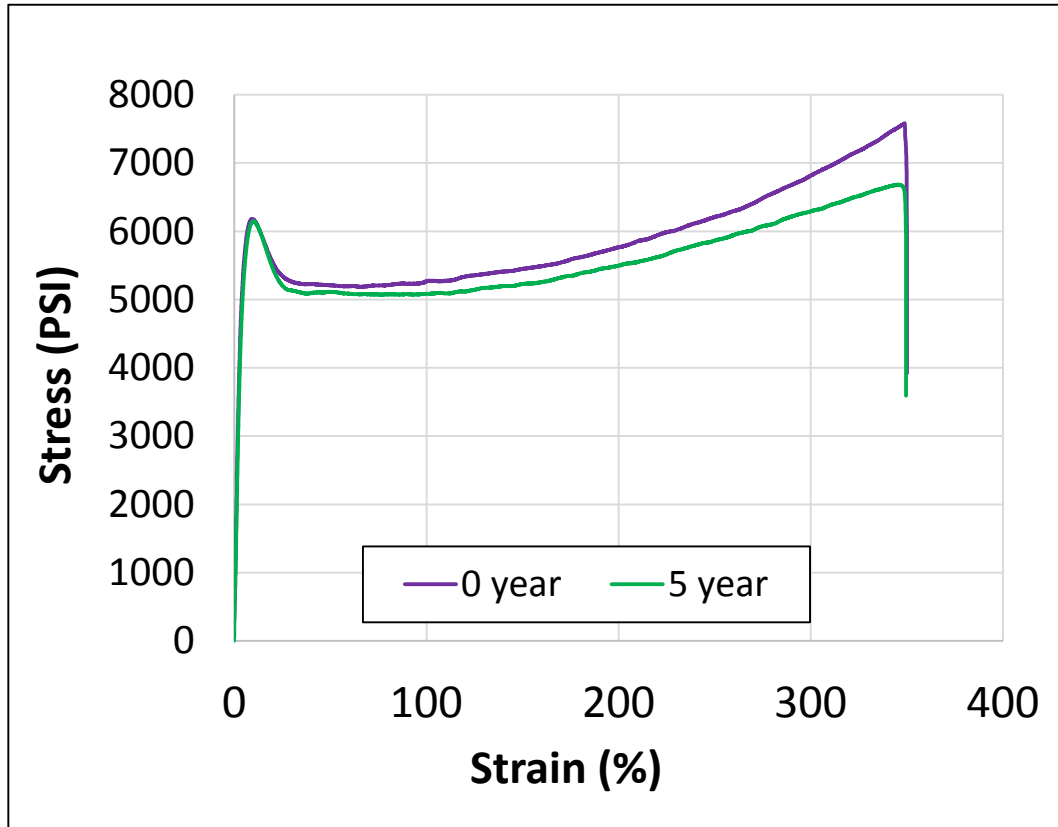


Film Thickness: 50 microns – except Kynar 2500 and Kynar 2750 at 125 microns

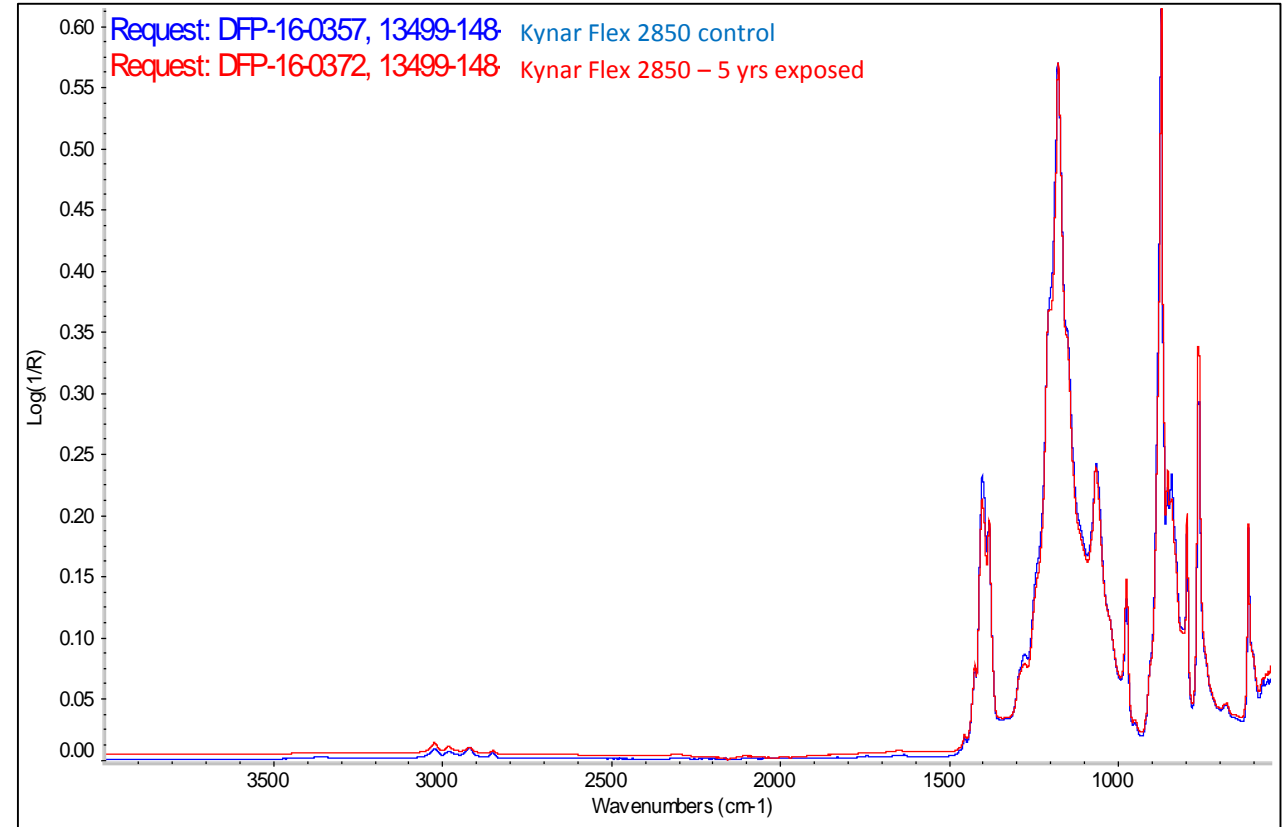
Tensile yield strength maintained at no loss of elongation: UV dosage > 1600 MJ/m²

MECHANICAL & CHEMICAL PROPERTIES OF KYNAR® FLEX FILMS BEFORE AND AFTER 5 YEARS OF EXPOSURE IN SOUTHERN FLORIDA

Kynar Flex® 2850 Tensile Stress-Strain



Kynar Flex® 2850 ATR- FTIR

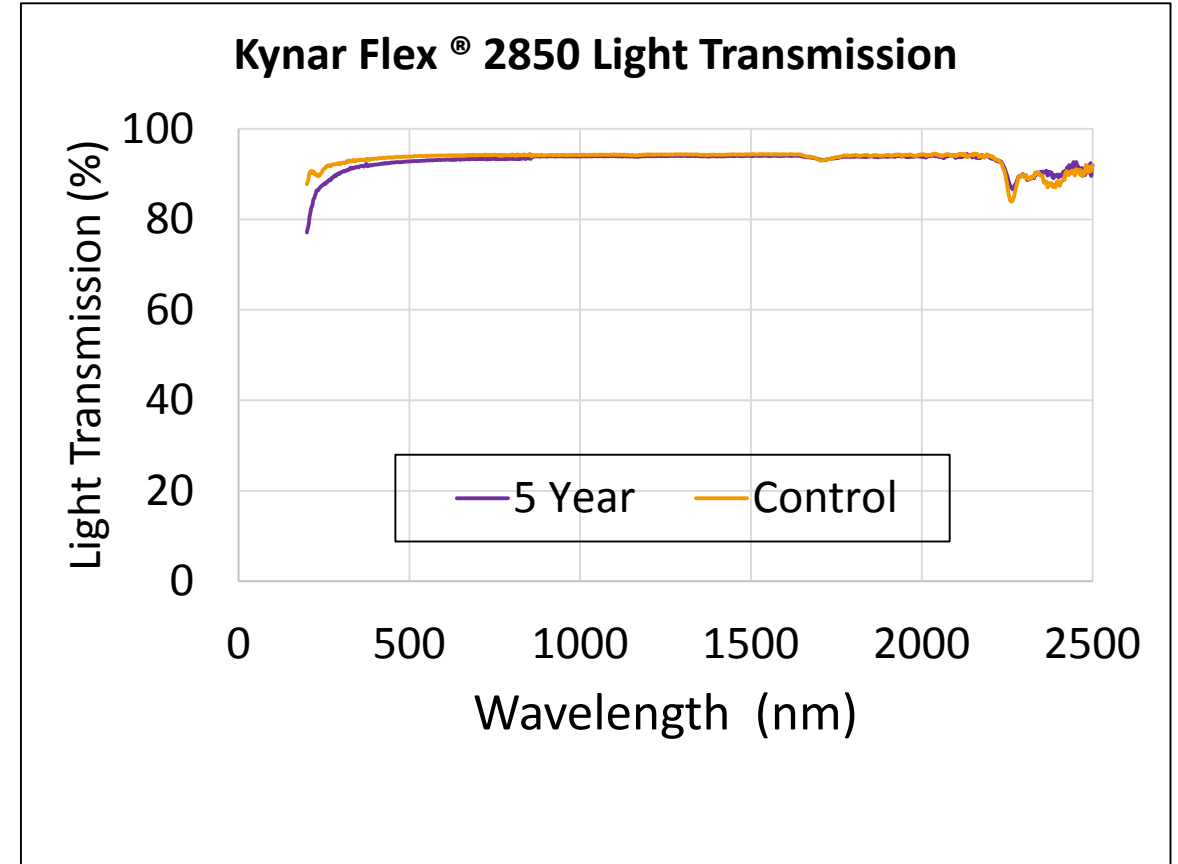
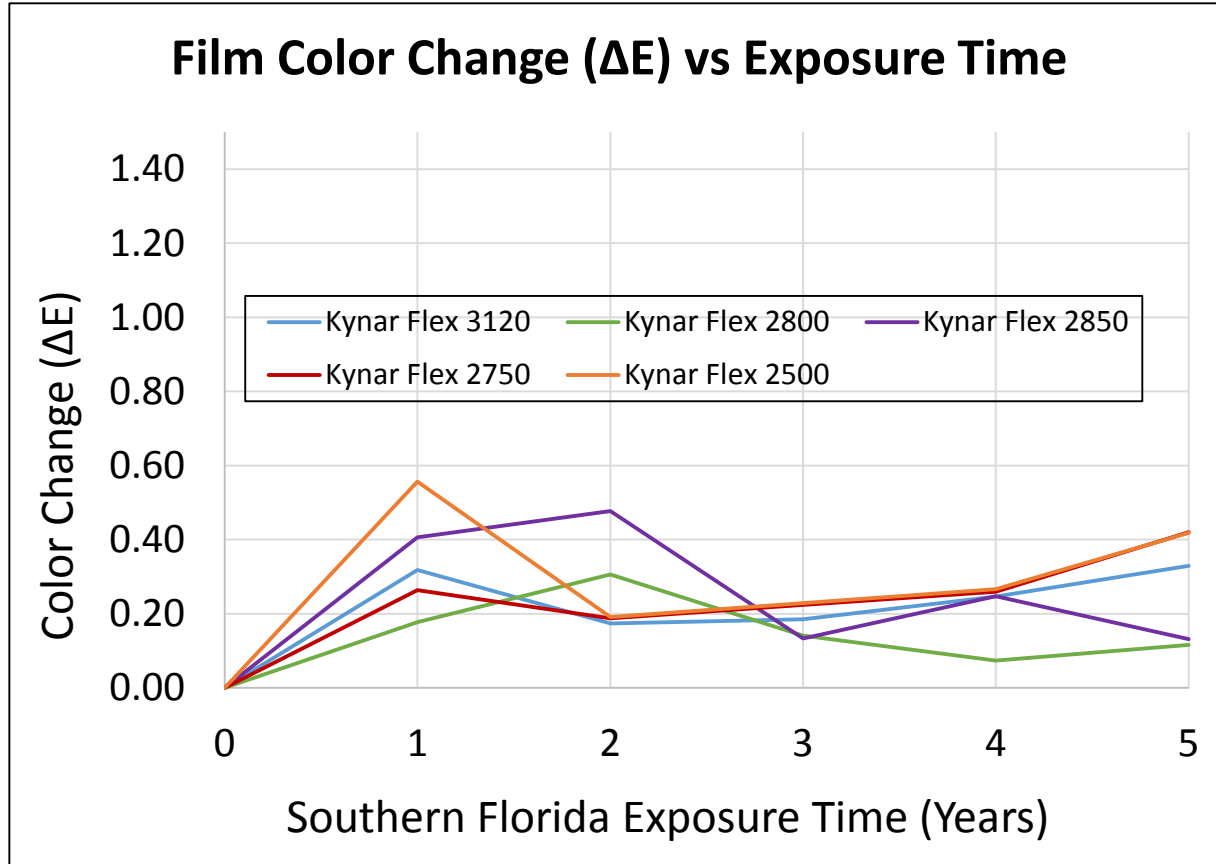


Full mechanical performance is maintained

No UV attack of polymer backbone by FTIR

OPTICAL PROPERTIES OF KYNAR® FLEX FILMS

BEFORE AND AFTER 5 YEARS OF EXPOSURE IN SOUTHERN FLORIDA

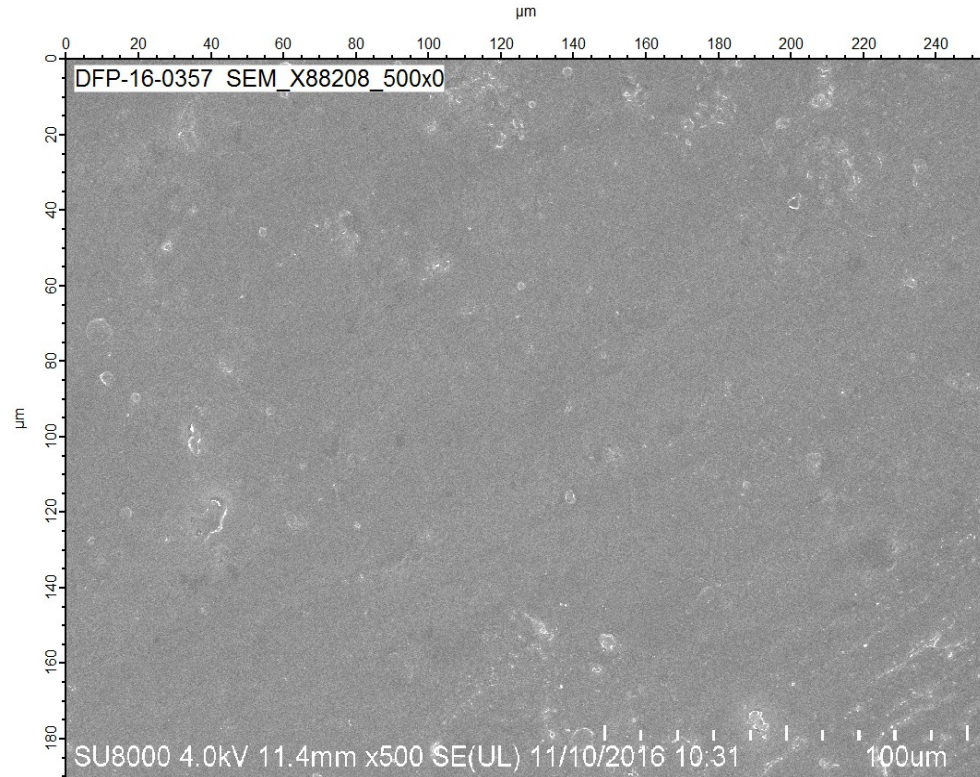


Color change is below the perception limit ($< \Delta E$ of 1.5)

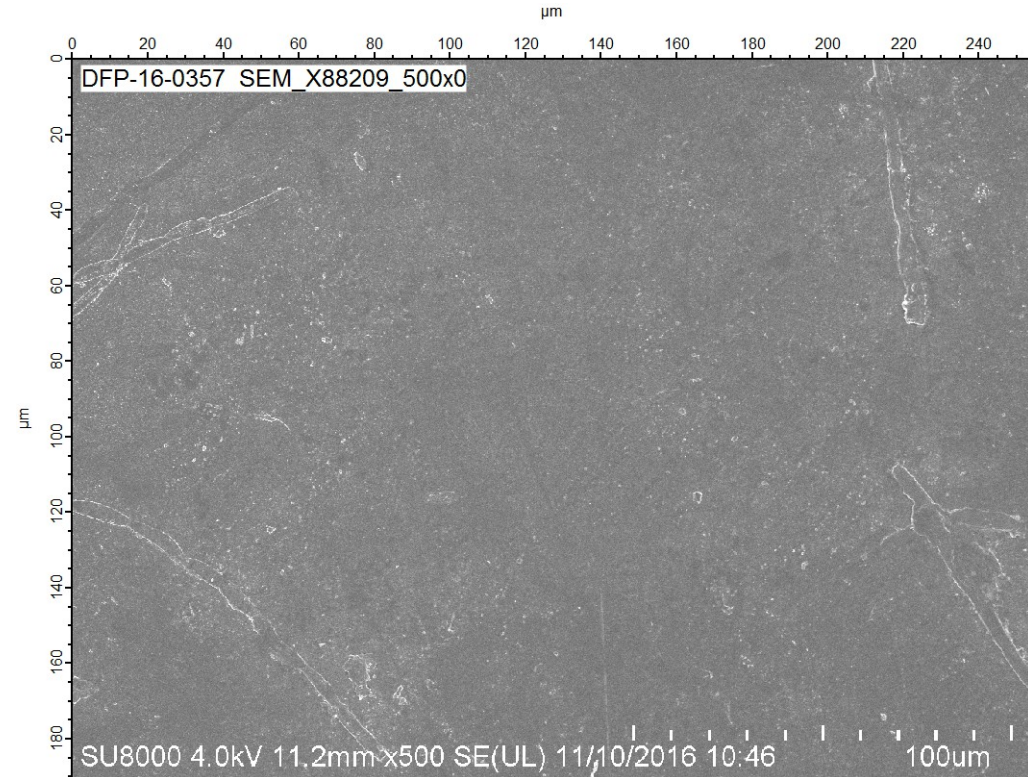
No color change and no significant change in light transmission show UV stability

KYNAR FLEX® FILMS SURFACE PROPERTIES

SEM MICROGRAPH – BEFORE AND AFTER 5 YEARS IN FLORIDA



Kynar Flex® 2850
Unexposed Film

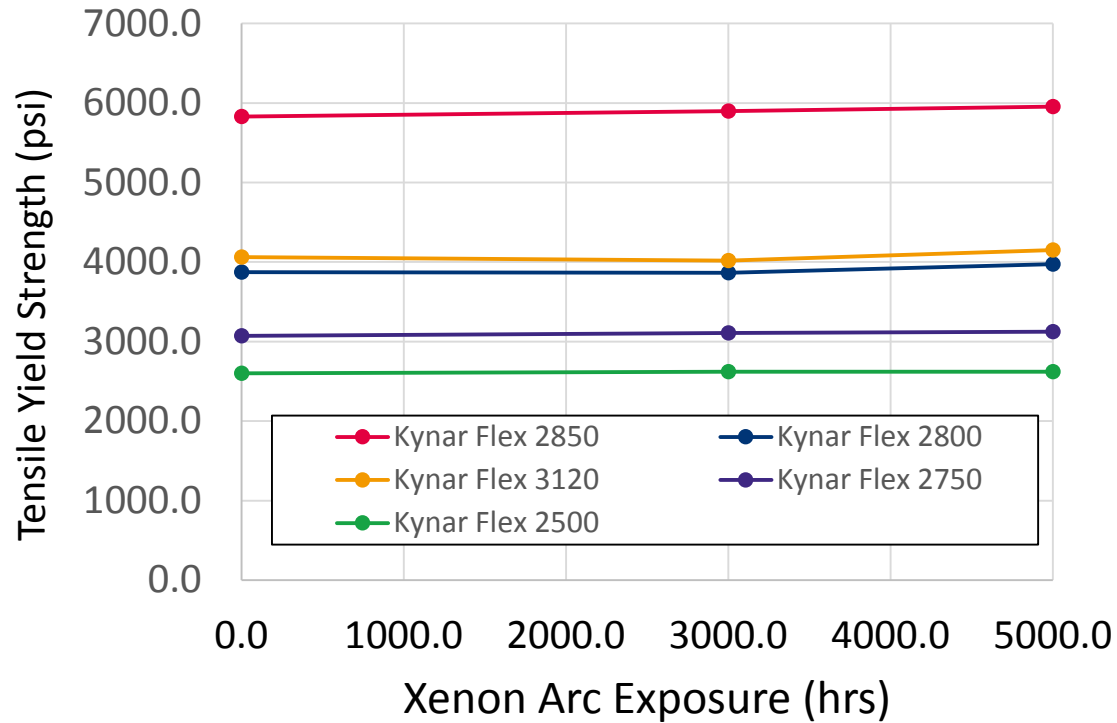


Kynar Flex® 2850
Exposed 5 Years in Florida

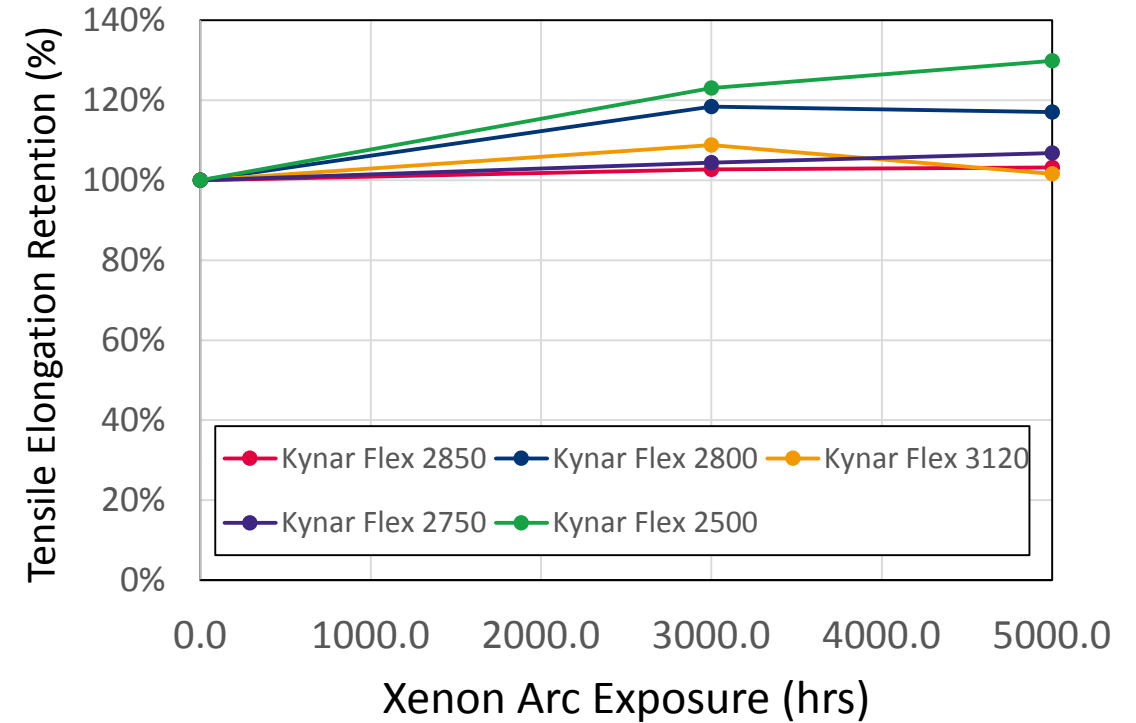
No surface erosion or pitting shows the extreme UV resistance of Kynar® Fluoropolymers

MECHANICAL PROPERTIES OF KYNAR FLEX® TENSILE BARS BEFORE & AFTER 5000 HR XENON ARC ACCELERATED WEATHERING EXPOSURE

Tensile Yield Strength (psi)



Tensile Elongation Retention (%)



Irradiance @ 340 nm of 0.8, 102 min of light with 18 min light & water spray
Chamber Temp = 70 °C , BPT = 95 °C
Samples = ASTM D638 type 1

Results clearly show no embrittlement or degradation in accelerated weathering

MECHANICAL PROPERTIES OF KYNAR FLEX® GRADES OFFERS OPTIONS STRENGTH AND FLEXIBILITY VARY – BUT ALL OFFER OUTSTANDING WEATHERING

Injection Molded Part Properties

Material	Exposure (hrs)	Stress at Yield (psi)	Strain at Break (%)	Tensile Modulus (psi)
Kynar Flex® 2850	0	5850	44	170,814
	3000	5900	46	178,697
	5000	5950	46	176,375
Kynar Flex® 3120	0	4050	135	117,022
	3000	4025	147	120,136
	5000	4150	137	115,333
Kynar Flex® 2800	0	3875	276	91,435
	3000	3865	327	93,598
	5000	3975	323	89,442
Kynar Flex® 2750	0	3075	353	65,440
	3000	3100	368	64,222
	5000	3125	377	66,292
Kynar Flex® 2500	0	2600	491	46,955
	3000	2625	604	48,524
	5000	2625	638	45,511

Extruded Film Properties

Material	Years	Thickness (µm)	Stress at Yield (PSI)	Stress at Break (PSI)	Strain at Break (PSI)
Kynar Flex® 3120	0	50	4,470	9,418	600
	5		4,397	6,720	631
Kynar Flex® 2800	0	50	4,229	9,246	605
	5		4,111	6,759	608
Kynar Flex® 2850	0	50	5,907	7,233	344
	5		6,048	6,475	348
Kynar Flex® 2750	0	125	2,870	6,814	675
	5		2,839	7,026	954
Kynar Flex® 2500	0	125	2,475	6,313	762
	5		2,472	6,562	1,126

A range of stiffness and strength offers component designers options
For applications where extreme weathering performance is critical

STRONG CABLE TIES – FOR EXTREME CONDITIONS

- ❖ Kynar® Films have shown outstanding weathering performance in PV backsheets
- ❖ Kynar Flex® grades show no changes in properties in outdoor & Xenon weathering
- ❖ Extreme weathering resistance, high strength and flexibility offer the designer choice to mold high performance cable ties
- ❖ One company – Nile Polymers in offering Kynar® cable ties.

<http://www.nilepolymers.com/strong-ty-cable-ties/>



Strong-Ty™ Kynar® Cable Ties

Strong-Ty™ cable ties made from Kynar® PVDF are ideal for environments where combinations of high temperature, chemical attack, radiation or mechanical stress limit other materials. These cable ties are durable and resist abrasion and mechanical damage during and after installation. With minimal flame-spread and smoke-generation Strong-Ty™ cable ties meet the National Electrical Code (NFPA-70A) and UL94V-0 requirements for installation in building plenum.

