Kynar® Fluoropolymer – A Solution for the Most Extreme Weathering Conditions

Poly-vinylidene fluoride (PVDF), a thermoplastic fluropolymer is selected by architects worldwide because of its proven long-term weathering resistance in outdoor environments. Plastics that are not modified may become brittle or weak over time and/or lose their original attractive appearance. This paper looks at the weathering stability of Kynar® resin in a thin film geometry after 5 years exposure in South Florida. Thin films are more sensitive to UV degradation than thicker specimens. Unlike traditional thermoplastics, Kynar® resins do not need UV or thermal stabilizers. This means that the stability seen in this test program is "built-in" to the backbone chemistry. Thus, their utility and performance in applications that require long-term outdoor protection is largely unrivaled.

Plastics are being utilized in a multitude of outdoor applications that previously were only reserved for inorganic materials due to their light weight, good insulation properties, safety to the touch, corrosion resistance, clarity, and range of color., Now, they have applications such as coatings, glazing, furniture, protective housing products, decking, signs, play areas, sports equipment, automotive and other transportation parts, chemical plant & industrial equipment, and fasteners. While the performance of plastics has often been found to be cost effective, safe, and attractive, there can at times be a major issue in resistant to sunlight. Plastics that are not modified may become brittle or weak over time and/or lose their original attractive appearance. Plastics that are modified with additives such as antioxidants can often last much longer in harsh conditions but there can still be concern that the modifiers do not stay in the polymer during storage before use and/or during processing. Having plastic materials that are inherently UV stable without additives can be a big advantage in extreme applications where long life with complete retention of properties is desired.

To put the comments above in perspective, Figure 1 shows Scanning Electron Microscope (SEM) images at 5000X magnification of various polymers after 5000 hours of QUVA accelerated weathering. While PVF, nylon, and phenolic based polymers show clear evidence of degradation and erosion, the Kynar® PVDF maintains its integrity and ability to continue to protect and serve as an outdoor weathering barrier or structure.

Kynar® resin is a highly nonreactive and pure thermoplastic fluoropolymer. The stability derived from vinylidene fluoride monomer [$(C_2H_2F_2)_n$-] actually comes from the high strength of the carbon-fluorine bond. The high fluorine content within the polymer backbone is not affected by UV exposure which normally degrades other polymers. Therefore, no additives are needed to stabilize Kynar® Fluoropolymers against the harmful effects of solar radiation. Thus, it has a proven history of exceptional UV protection, thermal and chemical resistance, moisture barrier properties, and dirt shedding performance.

The aim of this work is to assess how fluorine containing polymeric backbone can withstand extreme weathering conditions.
Thin films were chosen for this outdoor study to allow for a more sensitive weathering effect. Degradation can be seen much more quickly with film samples than with larger molded parts, where surface degradation can be masked due to the greater thickness of the samples.

This study examined six of the most widely used Kynar® thermoplastic fluropolymer grades. Each grade was made into a clear film using melt cast extrusion. Kynar® 720 resin is a homopolymer with

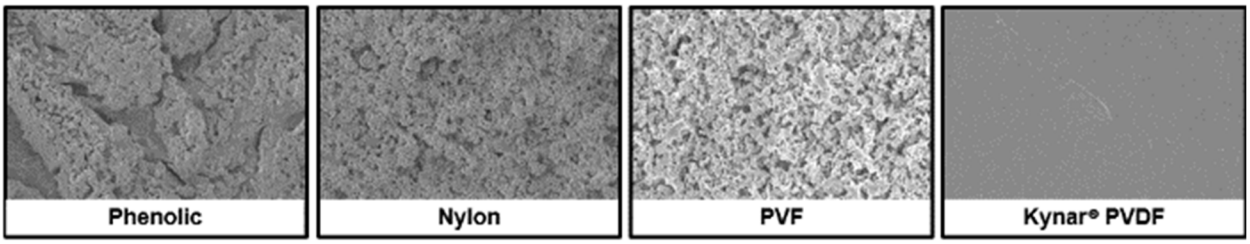

Figure 1: *Weathering Effects on Polymers*

higher strength and rigidity than the remaining five

Table 1: Kynar® PVDF Mechanical Properties

		Tensile and Elongation Properties				Retention (%)		
Material	Years	Thickness (μm)	Stress at Yield (psi)	Stress at Break (psi)	Strain at Break (%)	Stress at Yield	Stress at Break	Strain at Break
Kynar Flex® 3120	0	50	4,470	9,418	600	100%	100%	100%
	5		4,397	6,720	631	98%	71%	105%
Kynar Flex® 2800	0	50	4,229	9,246	605	100%	100%	100%
	5		4,111	6,759	608	97%	73%	101%
Kynar Flex® 2850	0	50	5,907	7,233	344	100%	100%	100%
	5		6,048	6,475	348	102%	90%	101%
Kynar Flex® 2750	0	125	2,870	6,814	675	100%	100%	100%
	5		2,839	7,026	954	99%	103%	141%
Kynar Superflex® 2500	0	125	2,475	6,313	762	100%	100%	100%
	5		2,472	6,562	1,126	100%	104%	148%
Kynar® 720	0	50	7,766	7,402	10	100%	100%	100%
	5		7,130	6,854	9	92%	93%	90%

Kynar Flex® copolymer grades.

Film samples were oriented at a 45° angle with south facing exposure and were placed for exposure in Miami, Florida where the annual yearly UV exposure is 360 MJ/m^2. The outdoor conditions in Florida allowed the samples to have an abundance of UV and weathering exposure, thereby providing data indicative of some of the world's harshest conditions. Since testing began in 2010, there have been no significant changes in the mechanical or optical properties of the film samples, as described below.

MECHANICAL PROPERTIES

As seen in Table 1, the mechanical properties of Kynar® clear films remain stable and relatively unchanged. Samples were tested in accordance with ASTM D882, the Standard Test Method for the Tensile Properties of Thin Plastic Sheeting. A representative stress strain curve, seen in Figure 1, shows no significant change in mechanical properties occurs over time. There is no loss in tensile yield strength or elongation despite the harsh weathering exposure.

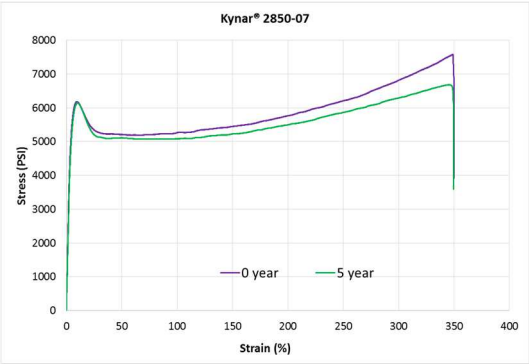

***Figure 2**: Stress Strain Curve*

OPTICAL PROPERTIES

The optical properties of Kynar clear films also remain unaffected by weathering. Changes in color are measured as a function of delta E*. As a rule of thumb, changes in delta E* greater than 2 are visible by eye. As seen in the figure below, none of the films have a delta E* greater than 0.80, well below the the threshold of significance.

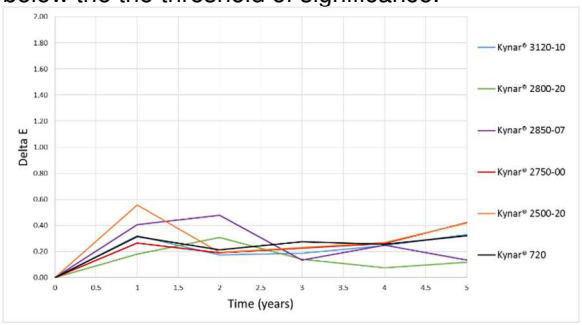

***Figure 3**: Measurements of Color Change*

Haze and transmission levels were recorded using the BYK-Gardner Haze-Gard Plus in Accordance with ASTM D1003. Again, no significant loss in transmission or haze properties is seen in any of the Kynar® clear films.

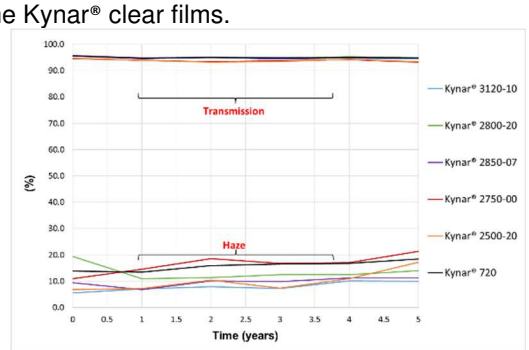

***Figure 4**: Haze and Transmission Measurements*

SURFACE PROPERTIES

The best way to prove weatherable nature of the Kynar® films is to examine the surface properties under high powered microscopy. Figure 5 shows a SEM image (100X magnification) of a representative film before exposure and after 5 years of weathering. The surface remains smooth with no signs of pitting or chalking.

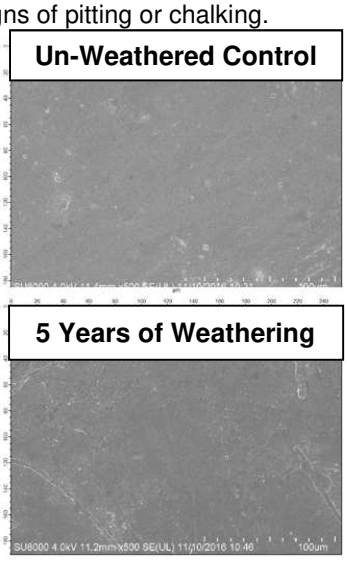

Figure 5: SEM Images

To check for any evidence of polymer degradation, FTIR scan was performed. As is seen in Figure 6. there is no IR evidence for degradation, as both (Control and weathered) spectral curves are overlaid, showing no significant change in the properties of Kynar® PVDF after five years of weathering.

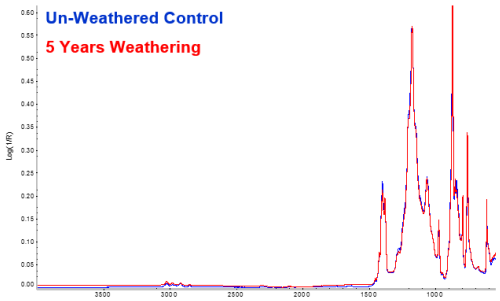

***Figure 6**: FTIR Spectrum*

APPLICATIONS

While clear films were examined in this study, the data suggests Kynar® PVDF can be considered for long life in numerous parts or products commonly used in outdoor applications. Pipes, hoses, tanks, automotive and aircraft parts and other injection molded or extruded parts that are used outdoors can benefit the owner/user by being made with Kynar® PVDF. Figure 7 shows a representative application of Kynar® cable ties commonly used in outdoor settings. The idea of this use of injection molded Kynar® PVDF is that if the use of the cable tie was on a high tower in a hard to get to a location exposed to extreme sunlight, there would be less worry about having to replace these fasteners over time compared to another polymer.

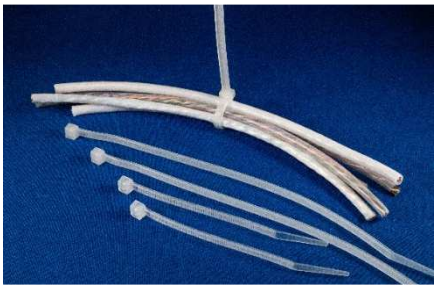

***Figure 7**: Kynar® PVDF cable ties*

SUMMARY

Kynar® PVDF has a history of superior weathering performance. Current work examining Kynar® PVDF placed in harsh outdoor conditions make it a unrivaled polymer choice for applications where UV radiation and other weathering phenomena are daily occurrences. With no fillers or stabilizers, Kynar® PVDF is a unique thermoplastic capable of withstanding extreme conditions just by utilizing the nature of its strong chemical backbone. The films examined show no changes despite having a geometry susceptible to degradation.

BIOGRAPHIES

Averie Palovcak received both a B.S. and M.S. in Biomedical Engineering from Drexel University. She is currently employed for Arkema Inc. as an application engineer for the Technical Polymers division. Averie has completed over 5 years of research on polymers used in drug delivery and has presented findings at the Harvard University and at the American Chemical Society meetings.

Bryan Douglas is employed for Arkema Inc as a Sr. Staff Technician in Fluoropolymers for 5 years with concentration focus in physical testing of polymers. He has worked in the area of polymers in Technical and R&D centers for the past 19 years. Bryan has 10 years in color matching and additive research experience for color concentrate companies. Bryan is currently a voting committee member of ASTM (D??).