ARKEMA

PHOTOVOLTAIC SOLUTIONS WITH KYNAR® PVDF

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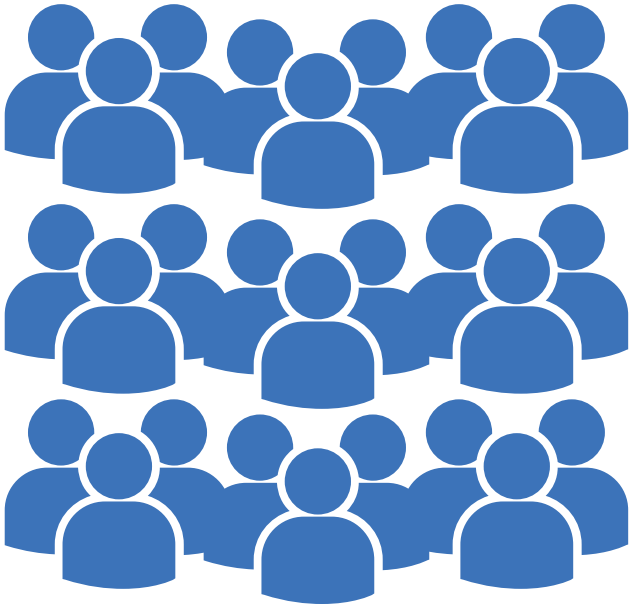
Photovoltaic Challenges

Evolving World → Evolving Industry

HIGHER VOLTAGES
1000V → 1500V

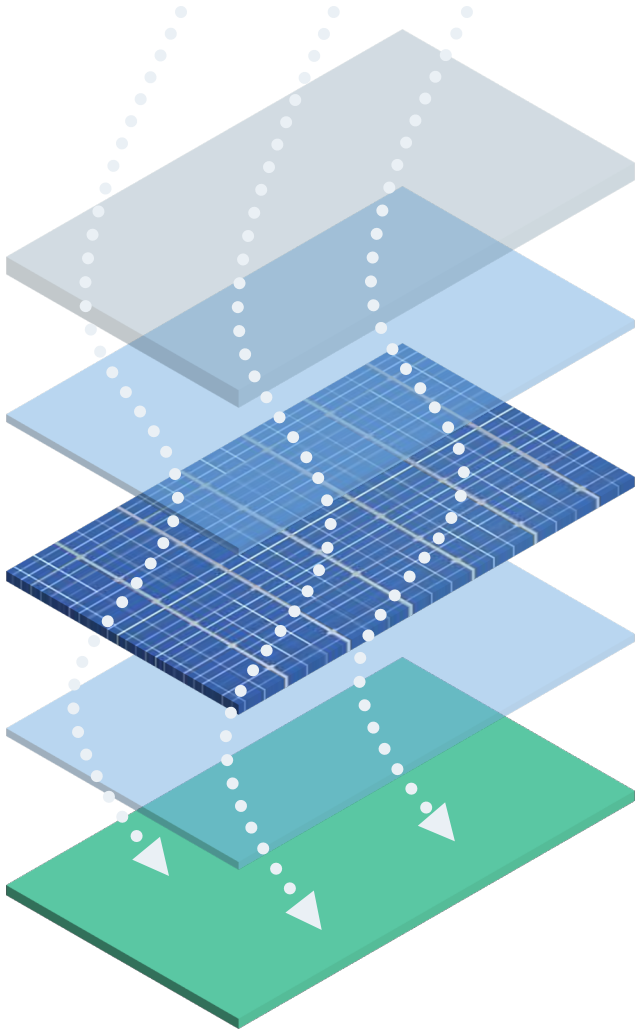
INCREASING UV EXPOSURE
MORE DURABILITY, FIRE HAZARDS

RISING DEMAND



INCREASING DEMAND FOR **LONG-LASTING SOLUTIONS**
→ **EXTREME ENVIRONMENTS** AND **REMOTE LOCATIONS**

Durability is Becoming more Important



Glass

EVA

Cell

EVA

Backsheet

PIVOTAL ROLE IN PV
PERFORMANCE AND **LONGEVITY**

BACKSHEET MATERIAL CHOICE
IS OF GREAT IMPORTANCE

Requirements of The Backsheet

WEATHERABILITY

- BARRIER PROPERTIES
- FLAME/SMOKE RESISTANCE
- CHEMICAL RESISTANCE
- RESISTANCE TO SAND EROSION
- HEAT STABILITY

UV PROTECTION

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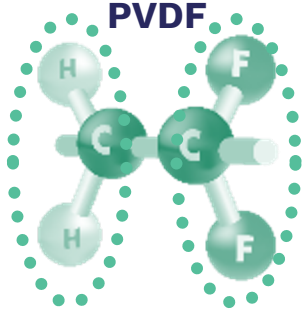
Performance Drivers

The Importance of Fluorine

KYNAR®

PVDF

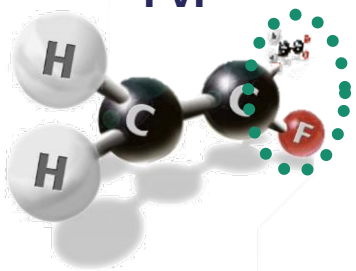


Easier processing

Higher performance

Alternative Fluoropolymer

PVF



Lower fluorine content

Important for
UV resistance and **Weathering**

Harsh Weather Conditions

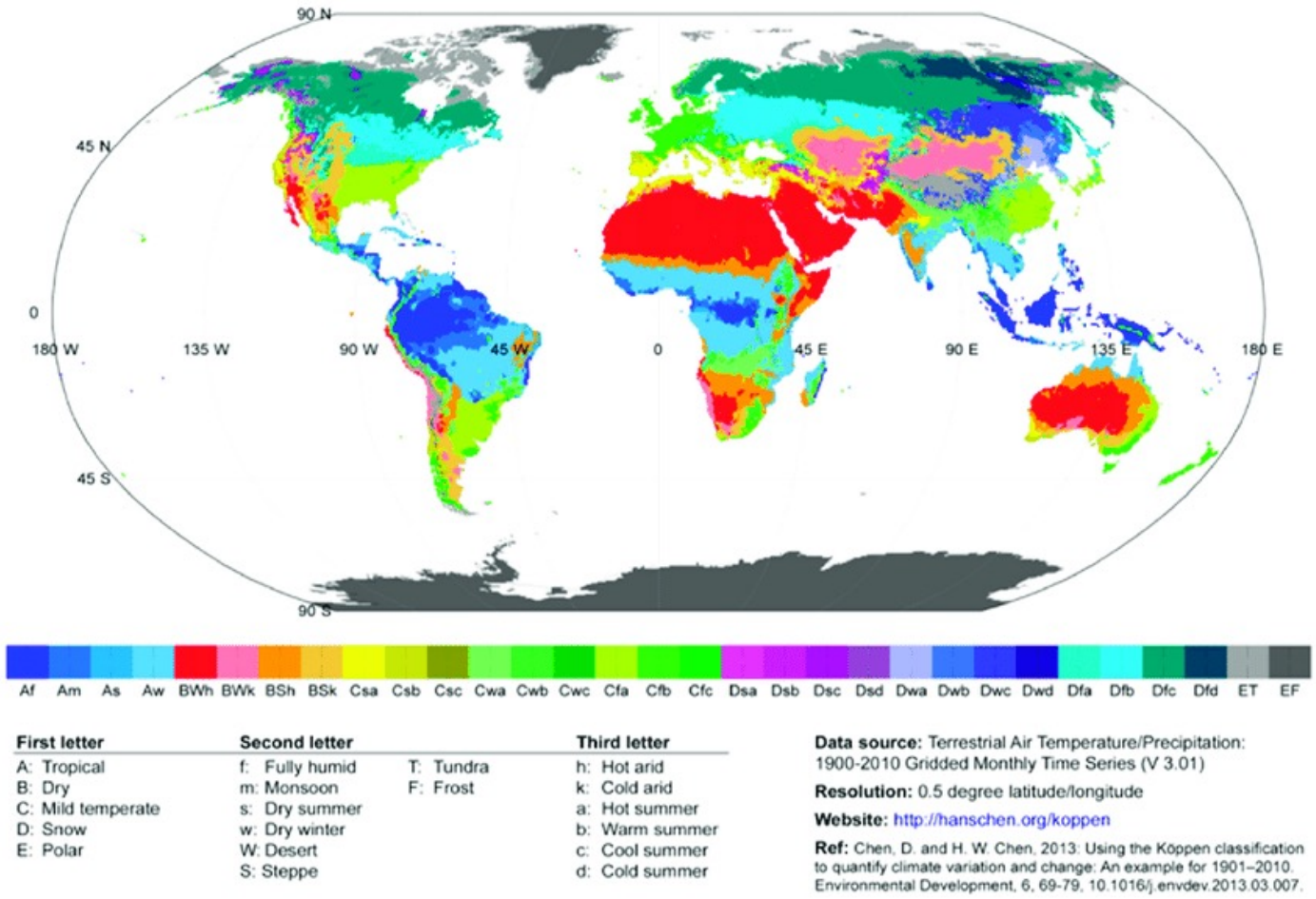
Indicative Reflextion coefficient:

Snow: 85-90 %

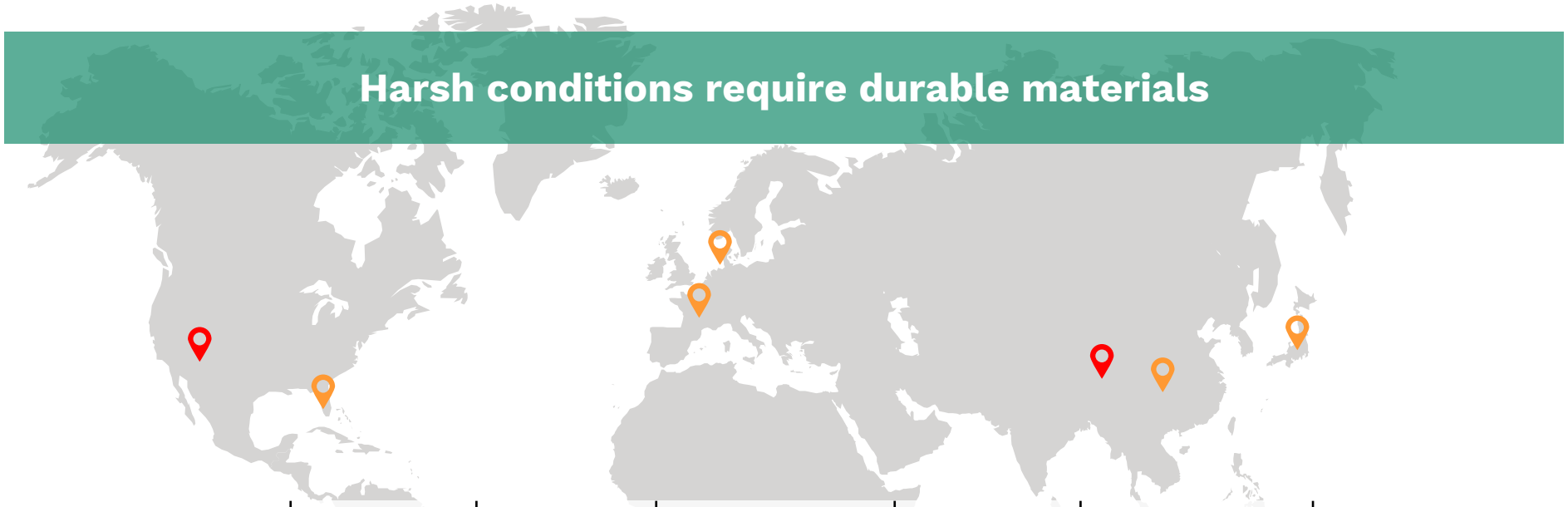
Sand: 15-20%

Sand (270µm) or Dust (100µm)

Concret 8-12%



UV Exposure Around the World



Harsh conditions require durable materials

Location	Climate	Annual UV (kWh/m²)	Annual Indirect UV (kWh/m²) assuming 15% ground reflection	25y dose of indirect UV (kWh/m²)	Equivalent QUVA Weathering time (h)	Equivalent Direct Exposure time in Florida (y)
Phoenix, AZ	Desert	91.7	13.7	342	5736	4.4
Miami, FL	Hot & Humid	77.8	11.7	292	4897	3.8
Sanary, France	Hot & Humid	79.2	11.9	297	4980	3.8
Choshi, Japan	Temperate	61.1	9.2	225	3773	2.9
Lochem, Netherlands	Temperate	56.8	8.5	212	3555	2.7

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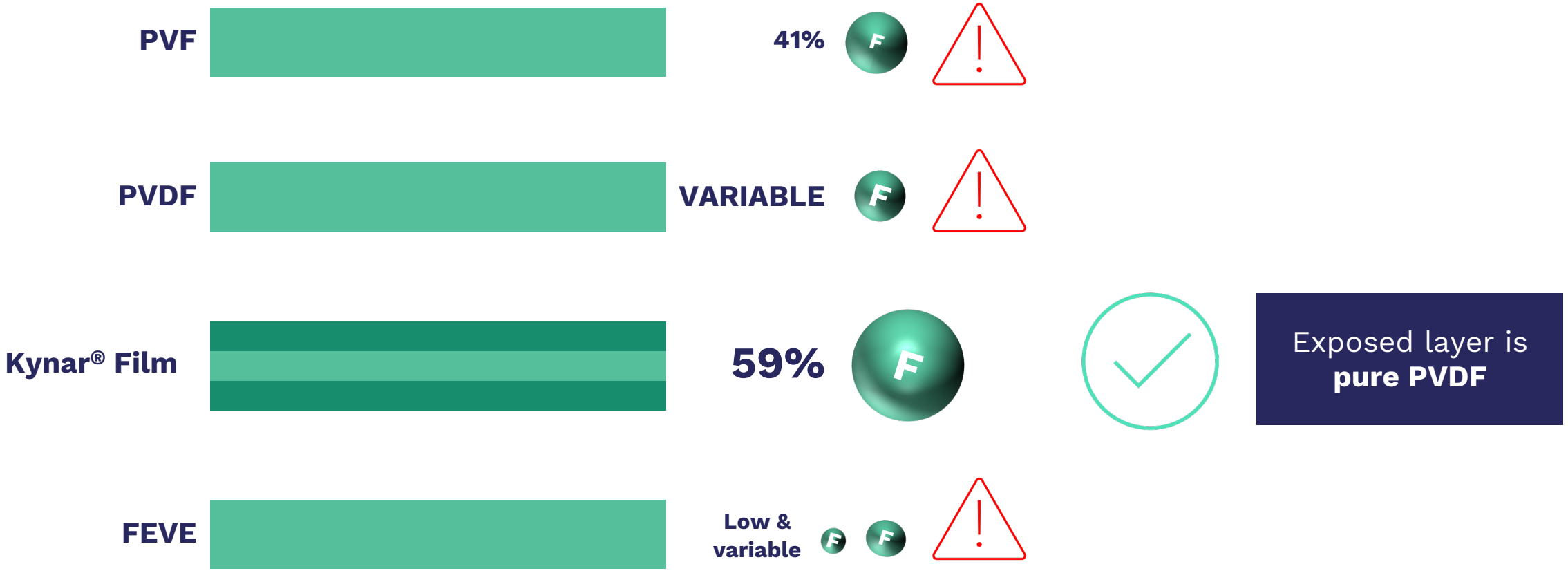
Focus On Kynar® Film

Why 3-Layer Kynar® PVDF Film ?



Patented 3-LAYER KYNAR® Film Technology

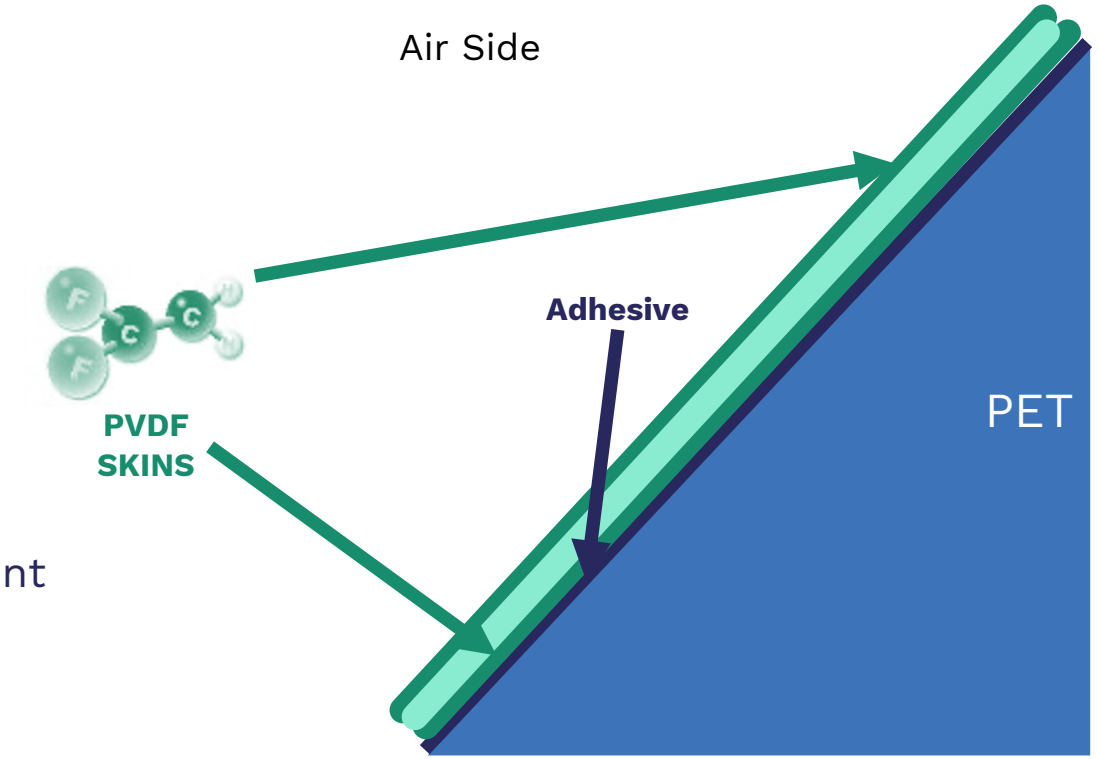
→ Surface layers: Pure **KYNAR® PVDF** with 59% Fluorine

- High Moisture Barrier
- Completely UV resistant
- Very broad Chemical Resistance
- High Flame resistance

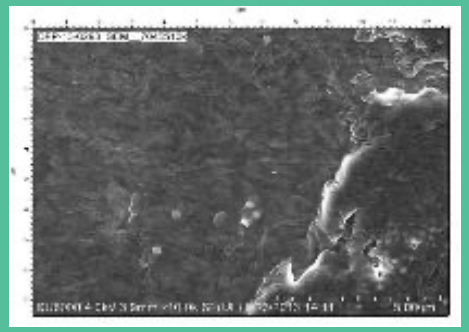
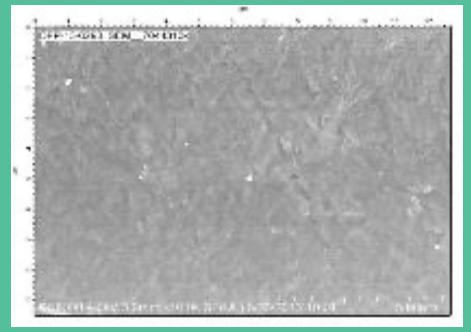
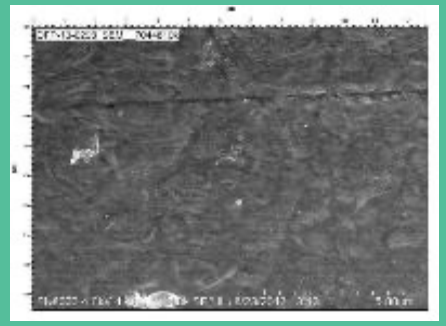
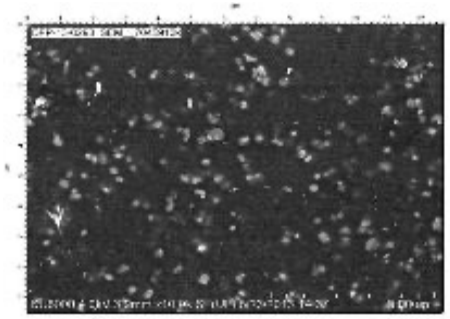
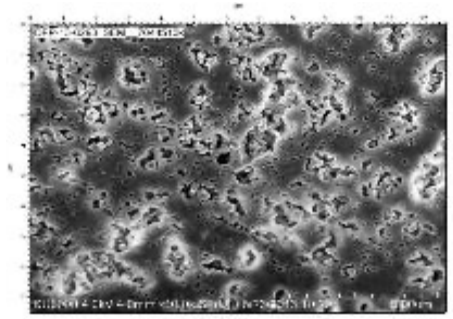
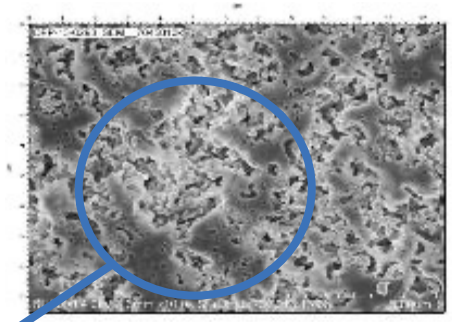
→ Middle pigmented layer: High **KYNAR® PVDF** content

- Same Fluorine content as Kynar 500 ®
- Permanently UV opaque

Pure Kynar® PVDF Skins = Absolute UV stability + Barrier against Moisture + Solvent resistance + Flame Resistance + High Thermal Resistance



PVDF Weathering Comparison

	t = 0 control	after 7800 hrs QUVA exposure	after 9200 hrs QUVB exposure
KYNAR® FILM			
PVDF Monolayer			

Variable PVDF formulations means UV degradation

→ **Competitive monolayer films are not pure PVDF !**

→ **Ask for the KYNAR brand to be sure !**

Holes
Cracks
Extreme Surface Erosion

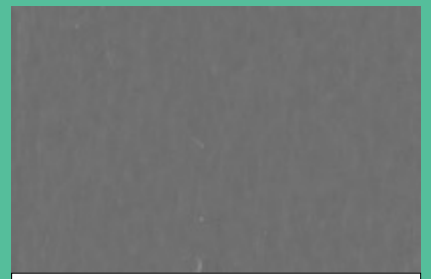
Film Thickness Before and After Weathering

Sample	Initial Film Thickness (microns)	Film Thickness after 7800 hrs QUVA (microns)	Film Thickness after 9200 hrs QUVB (microns)
KYNAR® FILM	28.4	28.9	28.7 ★
PVDF Monolayer	24.6	24.5	21.2

KYNAR® FILM is the only protective film which thickness is absolutly constant over exposure.

Kynar® Film versus PVF

Before ageing

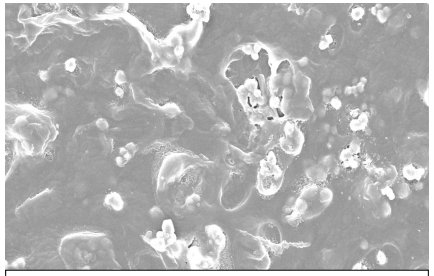


KYNAR® FILM unexposed

*After **5000 hours** of QUV b 313*

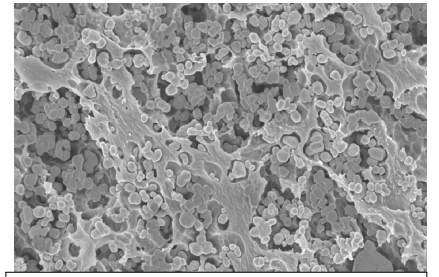
KYNAR® FILM exposed

Before ageing



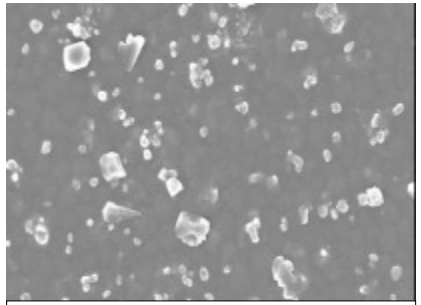
PVF 37.5 µm unexposed

*After **5000 hours** of QUV b 313*



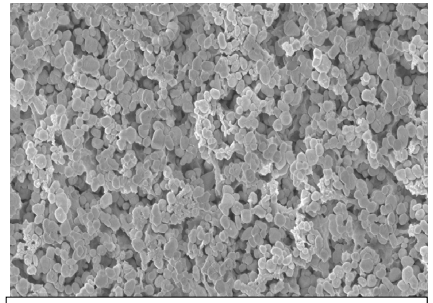
PVF 37,5 µm exposed

Before ageing



PVF 25 µm unexposed

After 5000 hours of QUV b 313

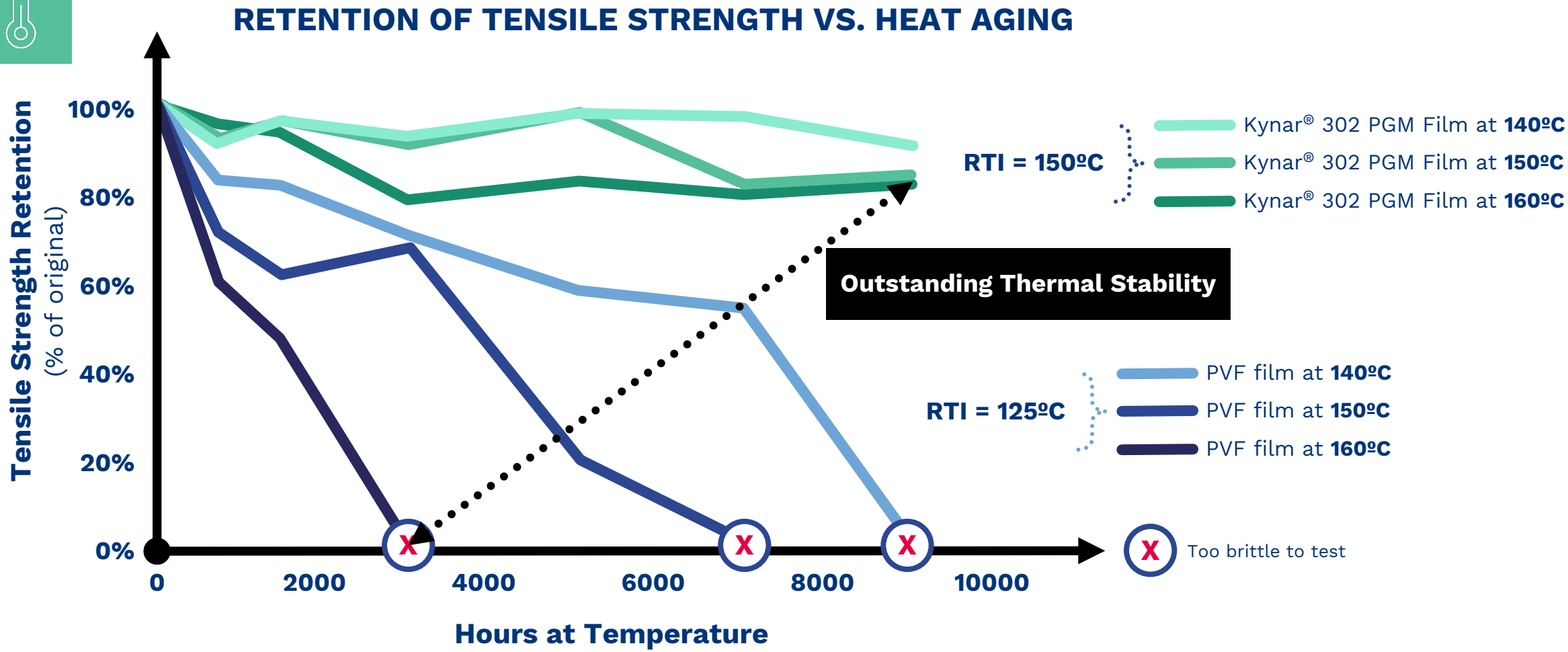


PVF 25 µm exposed

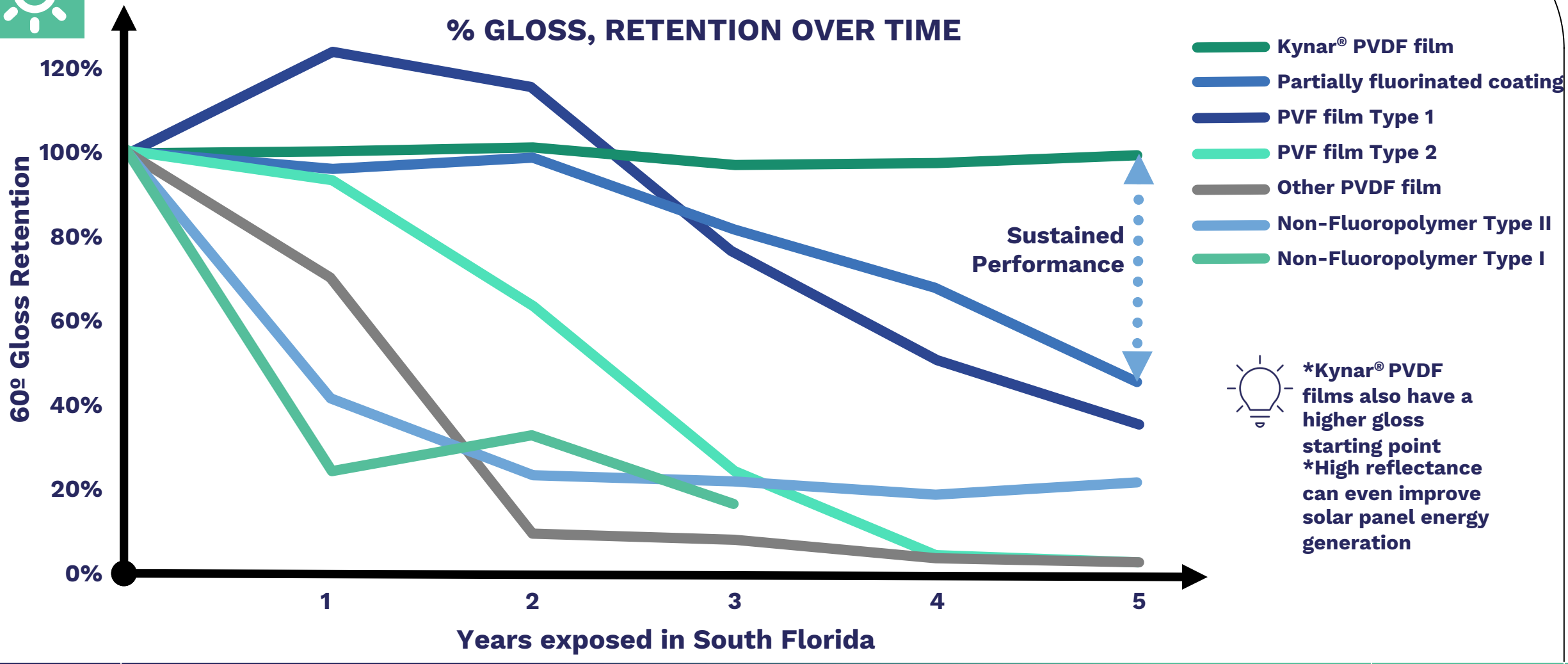
Fluorine content of PVF is 41%

KYNAR® FILM : 59% Fuorine content

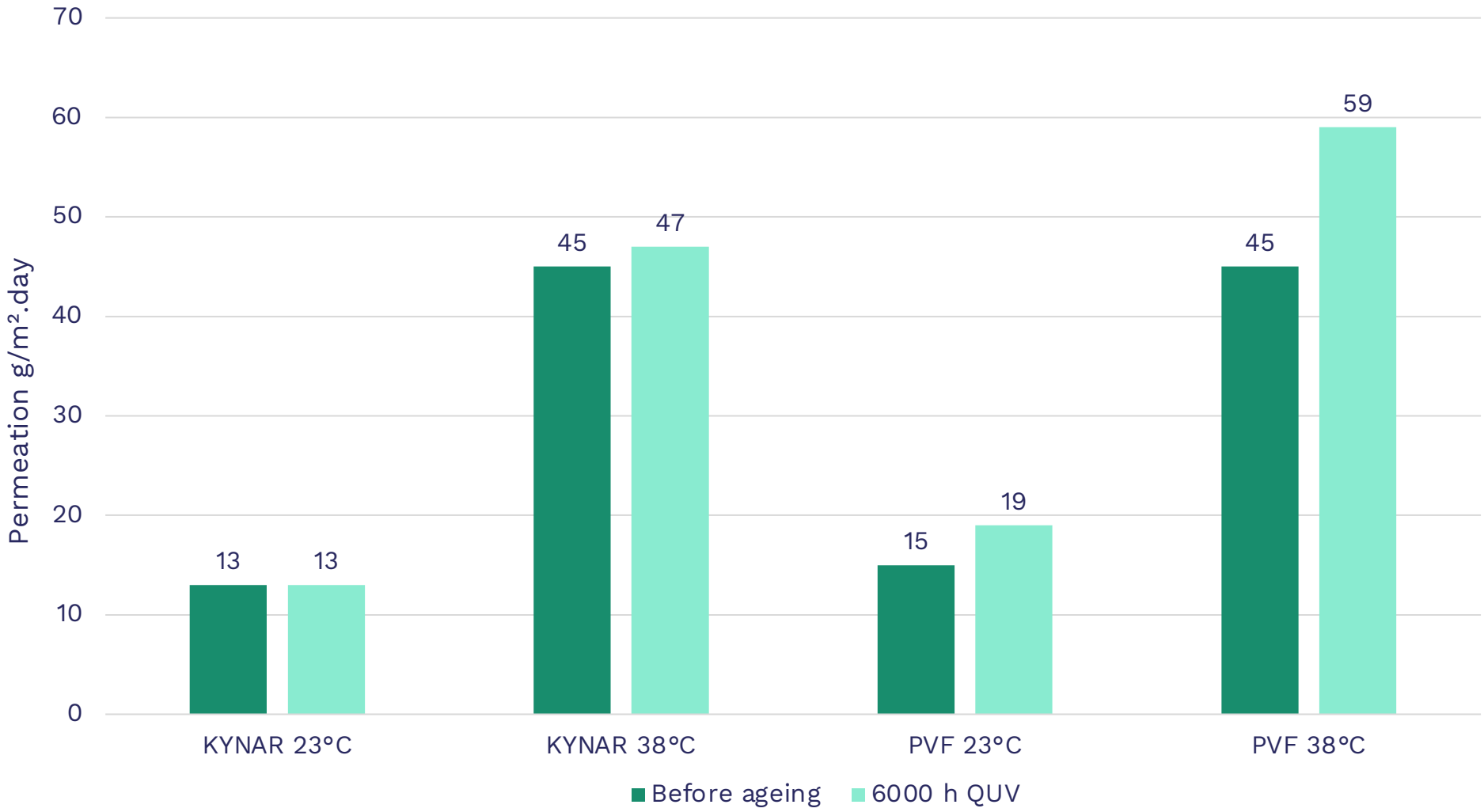
Kynar® Film – Thermal Stability



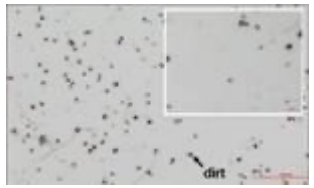
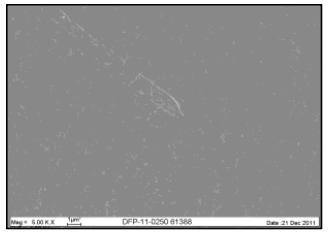
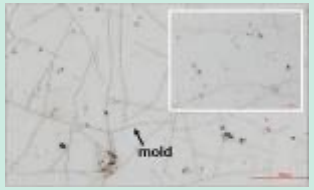
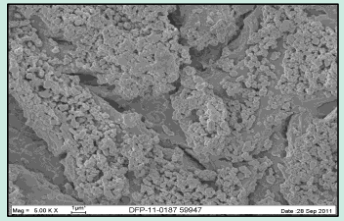
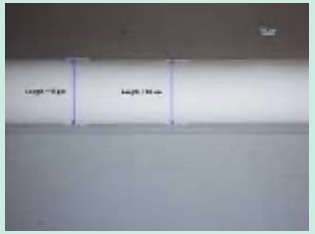
Kynar® Film – UV Resistance



Permeation Before & After UV Ageing



Is Kynar® Film Over-designed Versus Hydrolisys Resistant Pet?

	After 2 years exposure in Florida	After QUVA	Initial Thickness of the protective layer	Thickness of the protective layer after QUVA Aging
Kynar® Film protected Backsheet				
PET protected Backsheet				

→ **Severe degradation of the PET protective layer**

→ **40% Thickness reduction means**

- Breakdown voltage decrease > 24%
- Permeability increase x 1.7

Abrasion Resistance of Kynar® Film Vs. other Fluoropolymer Solutions

Problematic : Power plant (stand alone panels) with backside exposed to abrasion

Number of liters of sand until perforation to the PET

	Thickness of the coating µm	Liters of sand to perforate	Liters/25µm
PVF based backsheet	38	45	28.73
Kynar Film based backsheet	30	42	34.43
FEVE based BS	18	12	16.32

The KYNAR® FILM exhibits the best resistance to sand abrasion, even better than PVF for the same thickness and far better than FEVE coating.

Key Messages

WEATHERABILITY

- UV RESISTANCE
- FLAME/SMOKE RESISTANCE
- CHEMICAL RESISTANCE
- RESISTANCE TO SAND EROSION
- HEAT STABILITY

UL 94

- KYNAR® FILM has a unique multilayer structure
- KYNAR® FILM has UV and heat stable inner-composition like Kynar500®
- KYNAR® FILM shows no degradation, even after the most severe outdoor exposures
- KYNAR® FILM has positive track record since the beginning more than 10 years ago
- KYNAR® FILM has better UV and heat resistance than PVF.
- All PVDF competitive films are monolayer and have variable composition leading to variable properties

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