PHOTOVOLTAIC SOLUTIONS WITH KYNAR® PVDF

BACKSHEET FOCUS
ENERGY GENERATION WILL INCREASE MORE THAN 600% BY THE YEAR 2030

The dramatic growth in energy demand around the world is creating a rising demand for more efficient and lasting energy solutions. Solutions like solar panels will be exposed to even more extreme and remote environments, making the materials used in these applications even more important.

The world is becoming more extreme™
INVESTING IN SOLAR POWER PLANTS

1. Large Investment

2. Generate Electricity

3. Generate Monetary Return

MORE ENERGY

LONGER TIME
EVOLVING WORLD ➔ EVOLVING INDUSTRY

HIGHER VOLTAGES
1000V ➔ 1500V

INCREASING UV EXPOSURE
MORE DURABILITY, FIRE HAZARDS

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

RISING DEMAND
DURABILITY IS BECOMING MORE IMPORTANT

PIVOTAL ROLE IN PV PERFORMANCE AND LONGEVITY

BACKSHEET MATERIAL CHOICE IS OF GREAT IMPORTANCE
DURABILITY IS BECOMING MORE IMPORTANT

- More durable
- Higher energy production
- Safer Plant Environment
- Higher returns
- Less maintenance
PHOTOVOLTAIC CHALLENGES

PERFORMANCE DRIVERS

FOCUS ON KYNAR® FILM
<table>
<thead>
<tr>
<th>Location</th>
<th>Climate</th>
<th>Annual UV (kWh/m²)</th>
<th>Annual Indirect UV (kWh/m²) assuming 15% ground reflection</th>
<th>25y dose of indirect UV (kWh/m²)</th>
<th>Equivalent QUVA Weathering time (h)</th>
<th>Equivalent Direct Exposure time in Florida (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, AZ</td>
<td>Desert</td>
<td>91.7</td>
<td>13.7</td>
<td>342</td>
<td>5736</td>
<td>4.4</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>Hot &amp; Humid</td>
<td>77.8</td>
<td>11.7</td>
<td>292</td>
<td>4897</td>
<td>3.8</td>
</tr>
<tr>
<td>Sanary, France</td>
<td>Hot &amp; Humid</td>
<td>79.2</td>
<td>11.9</td>
<td>297</td>
<td>4980</td>
<td>3.8</td>
</tr>
<tr>
<td>Choshi, Japan</td>
<td>Temperate</td>
<td>61.1</td>
<td>9.2</td>
<td>225</td>
<td>3773</td>
<td>2.9</td>
</tr>
<tr>
<td>Lochem, Netherlands</td>
<td>Temperate</td>
<td>56.8</td>
<td>8.5</td>
<td>212</td>
<td>3555</td>
<td>2.7</td>
</tr>
</tbody>
</table>
## REQUIREMENTS OF THE BACKSHEET

### WEATHERABILITY
- Barrier Properties
- Flame/Smoke Resistance
- Chemical Resistance
- Resistance to Sand Erosion
- Heat Stability

### UV PROTECTION

![UV Protection Icon]
PROVEN MATERIALS FOR WEATHERING & UV PROTECTION

KYNAR® FLUOROPOLYMER PHOTOVOLTAIC SOLUTIONS

KYNAR® 500® FSF

ARKEMA
PROVEN TO BE THE WORLD’S MOST WEATHER RESISTANT COATINGS RESIN

KYNAR® FLUOROPOLYMER PHOTOVOLTAIC SOLUTIONS

Architects’ preferred metal coating brands

<table>
<thead>
<tr>
<th></th>
<th>50</th>
<th>58</th>
<th>91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand B</td>
<td>Brand A</td>
<td>Kynar 500®</td>
<td></td>
</tr>
</tbody>
</table>

Continuous Florida exposure since October 1967
GLOSS AND COLOR RETENTION

Withstands UV, high/low temperature, and chemicals over time
THE IMPORTANCE OF FLUORINE

Easier processing → PVDF → Higher performance

Alternative Fluoropolymer
PVF → Lower fluorine content

Important for UV resistance and Weathering
WHAT MAKES UP A BACKSHEET?

3 Key Layers

- Protective Film
- Polyester
- Protective Film

These layers can be optimized for enhanced UV and Weathering resistance.
## COMMON FILM SOLUTIONS IN THE MARKET TODAY

<table>
<thead>
<tr>
<th>Material</th>
<th>Fluorine Content (%)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVF</td>
<td>41%</td>
<td>![Warning Symbol]</td>
</tr>
<tr>
<td>PVDF</td>
<td>&lt; 50%</td>
<td>![OK Symbol]</td>
</tr>
<tr>
<td>3-Layer Kynar® PVDF</td>
<td>59%</td>
<td>![OK Symbol]</td>
</tr>
<tr>
<td>FEVE</td>
<td>&lt;&lt; 40%</td>
<td>![Warning Symbol]</td>
</tr>
</tbody>
</table>

*Exposed layer is pure PVDF*
ARKEMA PATENTED TECHNOLOGY

3-Layer Kynar® PVDF

- Protective Film
- Polyester
- Protective Film

Exposed layer is pure PVDF

KPK® Backsheet

PVF

- Protective Film
- Polyester
- Protective Film

Alternative Backsheet

Lower fluorine content diluted with pigments/additives
KYNAR® FILM – ADDED BENEFITS

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

LONGER LASTING IN MORE EXTREME ENVIRONMENTS
KYNAR® FILM – UV RESISTANCE

% GLOSS, RETENTION OVER TIME

60° Gloss Retention

Years exposed in South Florida

Kynar® PVDF film
Partially fluorinated coating
PVF film Type 1
PVF film Type 2
Other PVDF film
Non-Fluoropolymer Type II
Non-Fluoropolymer Type I

Sustained Performance

*Kynar® PVDF films also have a higher gloss starting point
*High reflectance can even improve solar panel energy generation

20

KYNAR® FLUOROPOLYMER PHOTOVOLTAIC SOLUTIONS
**KYNAR® FILM – THERMAL STABILITY**

**RETENTION OF TENSILE STRENGTH VS. HEAT AGING**

- **Kynar® 302 PGM Film at 140°C**
- **Kynar® 302 PGM Film at 150°C**
- **Kynar® 302 PGM Film at 160°C**

**RTI = 150°C**

- **PVF film at 140°C**
- **PVF film at 150°C**
- **PVF film at 160°C**

Outstanding Thermal Stability

Hours at Temperature

- 0
- 2000
- 4000
- 6000
- 8000
- 10000

Tensile Strength Retention (% of original)

- 0%
- 20%
- 40%
- 60%
- 80%
- 100%

**Too brittle to test**
PROVEN RESISTANCE TO CHEMICALS AND SAND EROSION

Decades of hot chemical exposure

Decades in desert conditions
CHOOSE A DURABLE SOLUTION FOR BACKSHEET FILM

Polyester

KPK® Backsheet

- Extreme performance
- Patented Technology
- The world’s most famous fluoropolymer for weather resistance
- Proven real world coating performance for over 50 years
PHOTOVOLTAIC SOLUTIONS WITH KYNAR® PVDF

BACKSHEET FOCUS

AN EXTREME WORLD NEEDS EXTREME MATERIALS