INDUSTRIAL MEMBRANES

Kynar® PVDF, when high performance matters
Kynar® PVDF is well established in the chemical processing industry for its excellent chemical resistance, mechanical strength, and long-term durability. These same qualities make this resin a great option for use in microfiltration and ultrafiltration membranes. Kynar® PVDF polymers are soluble in a variety of solvents, allowing them to be solvent-cast by the phase inversion process. Membranes made with Kynar® PVDF may be prepared as flat sheets, hollow fibers, and tubular configurations via the TIPS and NIPS processes.

Select Kynar® PVDF grades are USP Class VI compliant and listed in the federal register, NSF-51 and NSF-61, which allows the resins to be used in food contact and potable water applications. The outstanding chemical resistance of Kynar® resins allows a broad range of applications, including: potable water, high purity, and wastewater treatment. Medical applications include blood and protein filtration. Chemical filtration applications include food and beverage, biopharmaceutical, dairy, and paint.

**KYNAR® PVDF HIGHLIGHTS**

- 50+ year track record in PVDF production
- Outstanding Chemical Resistance i.e. ozone, chlorine, bromine, hydrogen peroxide, chlorine dioxide, acids
  - Homopolymer pH=1–12
  - Copolymers pH=1–13
- Grades available in a wide viscosity range for both flat sheet and hollow fiber membranes including both TIPS and NIPS processes
- Grades that produce highly durable anti-fouling membranes
- Select Kynar® PVDF grades used in membrane production are USP Class VI, NSF-51, and NSF-61 compliant
- Grades available for nanofiber production and nanofiber membranes
- Technical support teams have the ability to prototype hollow fiber, reinforced hollow fiber, and flat sheet membranes
- Radiation resistant and can be sterilized via conventional methods including gamma, steam, and EtOH

**KYNAR® PVDF MEMBRANE APPLICATIONS**

- Food & Beverage filtration
  - Water filtration (MF and UF pore size)
    - i.e. wastewater, viral rejection, ultrapure, deionized, potable water, membrane bio-reactors
  - Chemical process filtration (i.e. paint)
  - Biomedical blood and protein filtration
  - Biopharmaceutical filtration
  - Membrane distillation
  - Separations i.e. liquid/liquid, liquid/gas, gas/gas
  - Porous support for coating of specific separative layer(s) for gas/gas or liquid/gas separation
A GRADE FOR EVERY APPLICATION

A range of Kynar® PVDF grades are available to help customers tailor their membranes for specific applications and processing. The Kynar® 700 series is produced in a range of viscosities, permitting customers to select the optimum product for their membrane process. Kynar® MG 15 is a new grade designed specifically for hollow fiber spinning. Kynar® HSV 900 is a very high viscosity grade especially suitable for hollow fiber casting and other applications requiring high gel strength. Kynar Flex® copolymer grades offer even higher pH chemical resistance and greater flexibility.

Kynar® resins are supplied in several forms: fine powder, granular, and pellets. Powders are often preferred for ease of dissolution, while our new granular, high bulk density, free flowing G150 allows for easier handling and solubility. See table below.

TABLE 1
SOLUTION VISCOSITY (25°C @ 10S⁻¹)

<table>
<thead>
<tr>
<th>GRADE</th>
<th>Melt Visc (kp)</th>
<th>Solution Visc. 10% in DMAC (cps)</th>
<th>Solution Visc. 10% in NMP (cps)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>741</td>
<td>16 - 19</td>
<td>100 - 200</td>
<td>200 - 350</td>
<td>Good for TIPS hollow fiber (HF)</td>
</tr>
<tr>
<td>761</td>
<td>26 - 29</td>
<td>225 - 350</td>
<td>500 - 800</td>
<td>Good for TIPS hollow fiber (HF)</td>
</tr>
<tr>
<td>761A</td>
<td>32 - 35</td>
<td>- 450 - 650</td>
<td>1000 - 1500</td>
<td>Sheet membranes and NIPS HF</td>
</tr>
<tr>
<td>MG 15/ G150</td>
<td>36 - 39</td>
<td>700 - 900</td>
<td>1500 - 2000</td>
<td>High strength NIPS HF*</td>
</tr>
<tr>
<td>HSV900/G800</td>
<td>49 - 52</td>
<td>5000 - 7000</td>
<td>10000 - 15000</td>
<td>Low solids NIPS HF**</td>
</tr>
<tr>
<td>301F</td>
<td>27 - 30</td>
<td>450 - 550</td>
<td>800 - 1000</td>
<td>MF Membranes, supported fibers</td>
</tr>
<tr>
<td>2801</td>
<td>25 - 29</td>
<td>- 300 - 400</td>
<td>500 - 800</td>
<td>HFP Copolymer Improved Caustic Resistance &amp; Flexibility</td>
</tr>
</tbody>
</table>

* Specifically designed for robust hollow fiber spinning and producing high strength membranes.
** High viscosity grade that can be spun at low solids levels making it potentially attractive for membrane distillation.

TABLE 2
PHYSICAL, MECHANICAL, & THERMAL PROPERTIES

<table>
<thead>
<tr>
<th>Physical Properties*</th>
<th>Kynar® 700 Series</th>
<th>Kynar® MG Series</th>
<th>Kynar® HSV 900</th>
<th>Kynar® 301F</th>
<th>Kynar Flex 2801</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity D792/73°F (23°C)</td>
<td>g/cm³</td>
<td>1.77 - 1.79</td>
<td>1.75 - 1.77</td>
<td>1.76 - 1.79</td>
<td></td>
</tr>
<tr>
<td>Water Absorption % D570/68°F (20°C) Immersion/ 24 Hours</td>
<td>%</td>
<td>0.01 - 0.03</td>
<td>0.02 - 0.04</td>
<td>0.03 - 0.05</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical Properties*</th>
<th>Kynar® 700 Series</th>
<th>Kynar® MG Series</th>
<th>Kynar® HSV 900</th>
<th>Kynar® 301F</th>
<th>Kynar Flex 2801</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength @ 5% Strain D790/73°F (23°C)</td>
<td>psi (MPa)</td>
<td>8,500 - 11,000 (58-76)</td>
<td>7,000 - 9,000 (48-62)</td>
<td>3,000 - 5,000 (20-34)</td>
<td></td>
</tr>
<tr>
<td>Flexural Modulus D790/73°F (23°C)</td>
<td>psi (MPa)</td>
<td>240,000 - 335,000 (1,655-2,310)</td>
<td>200,000 - 250,000 (1,379-1,792)</td>
<td>70,000 - 120,000 (620-827)</td>
<td></td>
</tr>
<tr>
<td>Tensile Yield Elongation D638/73°F (23°C)</td>
<td>%</td>
<td>5 - 10</td>
<td>10 - 15</td>
<td>10 - 20</td>
<td></td>
</tr>
<tr>
<td>Tensile Yield Strength D638/73°F (23°C)</td>
<td>psi (MPa)</td>
<td>6,500 - 8,000 (45-55)</td>
<td>5,000 - 7,500 (34-52)</td>
<td>2,900 - 5,000 (20-34)</td>
<td></td>
</tr>
<tr>
<td>Tensile Break Elongation D638/73°F (23°C)</td>
<td>%</td>
<td>50 - 200</td>
<td>50 - 250</td>
<td>200 - 400</td>
<td></td>
</tr>
<tr>
<td>Tensile Break Strength D638/73°F (23°C)</td>
<td>psi (MPa)</td>
<td>5,000 - 8,000 (34-55)</td>
<td>4,500 - 7,000 (31-48)</td>
<td>2,500 - 5,000 (17-34)</td>
<td></td>
</tr>
<tr>
<td>Tensile Modulus D638/73°F (23°C)</td>
<td>psi (MPa)</td>
<td>200,000 - 335,000 (1,379-2,310)</td>
<td>150,000 - 200,000 (1,034-1,379)</td>
<td>80,000 - 130,000 (551-896)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermal Properties*</th>
<th>Kynar® 700 Series</th>
<th>Kynar® MG Series</th>
<th>Kynar® HSV 900</th>
<th>Kynar® 301F</th>
<th>Kynar Flex 2801</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt Temperature D3418</td>
<td>°F (°C)</td>
<td>323 - 342 (162 - 172)</td>
<td>311 - 320 (155 - 160)</td>
<td>284 - 293 (140 - 145)</td>
<td></td>
</tr>
<tr>
<td>Tg (DMA) @ 1 Hz D7028</td>
<td>°F (°C)</td>
<td>-41 - -37 (-40 - -38)</td>
<td>-41 - -37 (-40 - -38)</td>
<td>-42 - -39 (-41 - -39)</td>
<td></td>
</tr>
</tbody>
</table>

* Typical property values. Should not be construed as sales specifications.
ARKEMA, A GLOBAL LEADER IN INNOVATION
LET US SAVE YOU YEARS ON R&D

KYNAR® PVDF FOR MEMBRANES

- Characterization
- Anti-fouling
- Reinforced
  - Non-reinforced
- Flat sheet
- Custom additives
- Superhydrophobic & hydrophilic
- TIP & NIPS membrane processing
- Model formulations
- Applications engineering
- Hollow fiber

TECHNICAL SERVICE
Arkema, a leader in PVDF, is a global company with the resources to better serve our customers. Our experienced R&D staff and full analytical services provide us with the tools to prototype and test hollow fiber, reinforced fiber, and flat sheet membranes. Our team can provide initial formulations and process parameters for various grades of Kynar® PVDF to enable our customer’s development and speed to market.

- Model formulation
- Membrane spinning conditions
- On-site lab trials and training
- Field technical support
- Characterization
- Global support

CONTINUOUS INNOVATION

KYNAR® PVDF
- Higher strength membranes
- Durable anti-fouling
- Flex grades

NIPS HOLLOW FIBER PILOT LINE

CHLORINE AGING STUDY

NIPS CONCENTRIC HOLLOW FIBER
CHEMICAL RESISTANCE

KYNAR® PVDF MEMBRANES
- LOWER FOULING
- HIGHER DURABILITY
- LONGER LIFE

LONGER LIFETIME & MORE FORGIVING
NEW KYNAR® PVDF – DURABLE/ANTIFOULING GRADES

1,000,000 Cl⁻ ppm hours → >10 year lifetime

Less maintenance
Safer and more reliable
Kynar® resins have solubility properties suitable for easy processing by a variety of typical membrane forming processes. Table 3 lists active and latent solvents. Generally, Kynar® PVDF is not soluble in aliphatic hydrocarbons, aromatic hydrocarbons, chlorinated solvents, alcohols, acids, halogens, and basic solutions.

**TABLE 3**

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Boiling Point °C</th>
<th>Flash Point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethyl Acetamide a</td>
<td>166</td>
<td>70</td>
</tr>
<tr>
<td>N-Methyl-2-Pyrrolidone a</td>
<td>202</td>
<td>95</td>
</tr>
<tr>
<td>Dimethyl Formamide</td>
<td>153</td>
<td>67</td>
</tr>
<tr>
<td>Dimethyl Sulfoxidec (DMSO) b</td>
<td>189</td>
<td>88</td>
</tr>
<tr>
<td>Triethyl Phosphate</td>
<td>215</td>
<td>116</td>
</tr>
<tr>
<td>Tetramethyl Urea</td>
<td>177</td>
<td>1165</td>
</tr>
</tbody>
</table>

a Most commonly used solvents.
b DMSO is a product offered by Arkema
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