WATER SOLUTIONS WITH KYNAR® PVDF

WATER FILTRATION FOCUS
Nearly 1 billion people do not have access to clean drinking water.

Our world depends on water. The fact that over 10% of the population does not have access to clean water creates a huge need for innovative solutions in the water filtration market. The success of these developments is highly dependent on material innovations.
DRIVERS IN THE MARKET

CLEAN WATER
- Poor quality of ground/surface water
- Scarcity of freshwater

URBANIZATION

PLANT FOOTPRINT
- Plants are required to operate beyond their design capacity/capabilities

SEVERE CHEMICALS
- Cl → ClO₂, NaOCl, and Chloramines
- Much more extreme oxidization

WATER MARKET PRESENTATION
A VARIETY OF END APPLICATIONS

“Showers to Flowers”
10% reintegration with potable water
Re-use of polluted water

More pollutants added each cycle

Potential for pollutants reaching our food

Ultra-Filtration can be used here
CLASSIFICATIONS OF MEMBRANES

<table>
<thead>
<tr>
<th>Pore Size</th>
<th>Filtration Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10µM</td>
<td>Macroparticles</td>
</tr>
<tr>
<td>0.1-1µM</td>
<td>Sand filtration = &lt; 10psi</td>
</tr>
<tr>
<td>0.01-0.1µM</td>
<td>Microfiltration (MF) = 10-30psi</td>
</tr>
<tr>
<td>1-10nm</td>
<td>Ultrafiltration (UF) = 15-35psi</td>
</tr>
<tr>
<td>0.01-1nm</td>
<td>Nanofiltration (NF) = 80-150psi</td>
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</table>

- Turbidity
- Algae
- Giardia
- Cryptosporidium
- Bacteria
- Organic Macromolecules
- Asbestos
- Virus
- Organic Chemicals
- Hardness
- Color
- Radionuclides
- Metal Ions
- Salt
- Brackish Reverse Osmosis (BRO) = 150-300psi
- Seawater Reverse Osmosis (SWRO) = 500-900psi
WHY DO WE NEED MF & UF?

Sand filtration usually starts with “safe water”

There is wide variability in how safe the “safe water” really is

Sand filtration CANNOT remove potentially harmful bacteria and viruses

Macroparticles

Sand filtration = < 10psi

Turbidity  Algae  Giardia  Cryptosporidium  Bacteria

Microfiltration (MF) = 10-30psi

Organic  Macromolecules

Asbestos  Virus

Ultrafiltration (UF) = 15-35psi

8
A COMMON THREAD OF REQUIREMENTS

Chemical Resistance

Flexibility & Toughness

Process Flexibility

Regulatory Certifications

PFOA Free

Fluorosurfactant Free
HALOGEN RESISTANCE

- Chlorine resistance
- NaOCl (Bleach) resistance
- Chloramine resistance
- Chlorine dioxide resistance

Far better halogen resistance than PSU and PES
ACID & OXIDIZER RESISTANCE

Also good resistance to aromatics, chlorinated solvents, and hypochlorous acid (HOCl)
Chemical resistance of KYNAR® PVDF

Chemical effect on elongation

- Control
- HCl (pH 1)
- NaOH (pH 13)
- NaOCl (3000 ppm, pH 9.5)
- Cl water (3000 ppm) or NaOCl (pH 6)
- Br water (3000 ppm)

Percentage elongation

0.2µm samples exposed for 14 days @ 45°C
LONGER LIFETIME AND MORE FORGIVING

PES

50,000
Cl⁻ ppm hours → 3-5 year lifetime

VS.

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

KYNAR® by Arkema

Replace often
Time/Resource cost

Less maintenance
Safe and reliable
A COMMON THREAD OF REQUIREMENTS

- Chemical Resistance
- Flexibility & Toughness
- Process Flexibility

Regulatory Certifications
- PFOA Free
- Fluorosurfactant Free
Turbulent water flow leads to:
- Excessive membrane stress
- Cracking of membrane
- Broken membrane

Kynar® PVDF
- High ductility
- High elongation
- Good resilience
FLEXIBILITY AND TOUGHNESS

STRESS-STRAIN for PSU/PES vs. Kynar® MG15

- Much Higher Ductility
- More Energy Required to Break
- Longer Lasting Membrane
A COMMON THREAD OF REQUIREMENTS

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CLASSIFICATIONS OF MEMBRANES

NIPS
(non-solvent-induced phase separation)

ONLY
PVDF

TIPS
(thermally-induced phase separation)

WIDE RANGE OF SOLUTION VISCOSITIES

FLEXIBLE PROCESSING

HOLLOW FIBER, FLAT SHEET, SUPPORTED, UNSUPPORTED

Flat Sheet

Hollow Fiber
PROCESSING BENEFITS OF KYNAR® PVDF

GOOD SPINNING PROPERTIES

- Hollow fiber spinning
- Stable solution spinning
- Better mechanical properties
- Consistent macro-void-free fibers

SOLVENT COMPATIBILITY

- Strong solvents
  - NMP
  - DMAc
  - DMSO

GRANULAR & POWDER GRADES

- High bulk density
- Easier flow
- Low dusting
KYNAR® PVDF FOR FILTRATION MEMBRANE

Available grades

NIPS – FLAT SHEET

- Kynar® 761A
- Kynar® 761

NIPS – HOLLOW FIBER

- Kynar® MG15
- Kynar® 761A
- Kynar® 761

TIPS – HOLLOW FIBER

- Kynar® 761
- Kynar® 741
# KYNAR® PVDF FOR FILTRATION MEMBRANE

## Solution viscosity run @ 10% wt in NMP, 20°C, 10s-1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Melt Visc (kp)</th>
<th>Solution Visc (cps)</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>741</td>
<td>16 – 22</td>
<td>100 – 200</td>
<td>Good for TIPS HF</td>
</tr>
<tr>
<td>761</td>
<td>25 – 29</td>
<td>300 – 450</td>
<td>Sheet membranes and TIPS HF</td>
</tr>
<tr>
<td>761A</td>
<td>30.5 – 35.5</td>
<td>850 – 1400</td>
<td>Sheet membranes or hollow fiber</td>
</tr>
<tr>
<td>MG15</td>
<td>35 – 38</td>
<td>1500 – 1900</td>
<td>Ideal for hollow fiber</td>
</tr>
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KYNAR® PVDF FOR MACRO-VOID-FREE MEMBRANES
KYNAR® MG15 – KEY BENEFITS

**Processing**
- High Solution Viscosity
- High Gel Strength
- Good Spinning Stability

**Small Pore Size**
- Produce membranes with pores < 50nm
- Great for UF Membranes

**Strength**
- Uniform macro-void free membranes
- High Strength Membranes
- Long-Life Membranes

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KYNAR® PVDF FOR HIGH STRENGTH NIPS – UF MEMBRANES

NEW TECHNOLOGY

BASED ON KYNAR® MG15

Produce high strength hollow fibers without TIPS processing

High Strength

5-7MPa

High Permeability

>600 LMHB
\((L*m^{-2} \text{ hr}^{-1} \text{ bar}^{-1})\)
**DURABLE HYDROPHILIC MEMBRANE SOLUTIONS**

**Patented Arkema Technology**

- Uniform Macro-Void-Free UF membranes
- High Flux High Strength
- Tailored Functionality
- Permanently Low Fouling
- Stable performance through a lifetime of chemical cleaning

**Structure of copolymers Grafted onto Kynar® PVDF**

- Pore ≥10 nm
- Block miscible with PVDF
- Hydrophilic block

**Grafted onto Kynar® PVDF**
SUSTAINED HYDROPHILICITY OVER LIFETIME

MEMBRANES AFTER 250,000 ppm hours Cl⁻

Relative Permeability (%) vs. Cumulative Flow (L/m²)

- Arkema Fouling Resistant Membrane
- Commercial #1
- Commercial #2
Let us save you YEARS of R&D

- Model formulation
- Membrane spinning conditions
- On-site lab trials and training
- Field technical support
- Characterization
- Global support
WATER SOLUTION WITH KYNAR® PVDF

WATER FILTRATION FOCUS