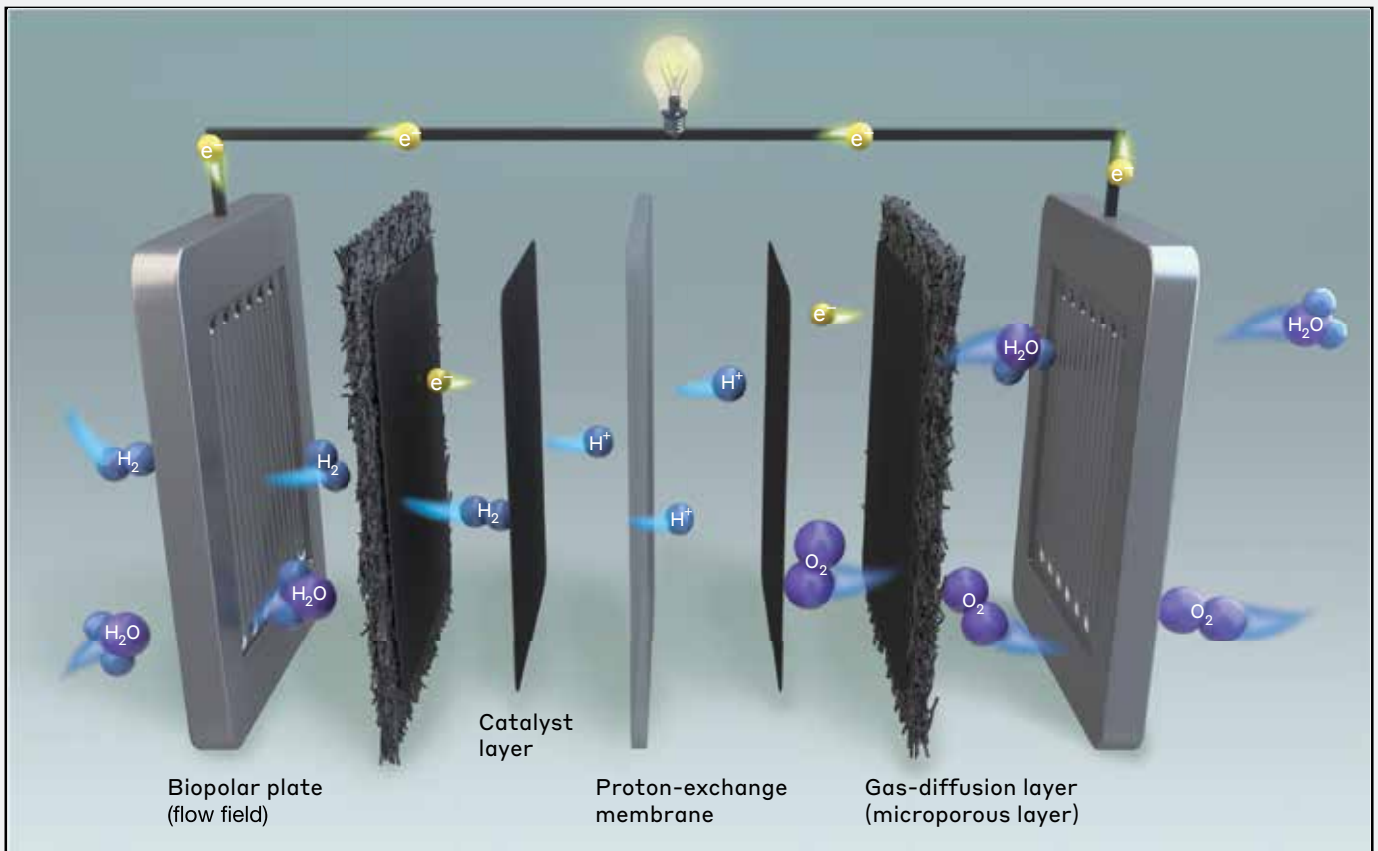




PEMION® FUEL CELL OFFERINGS

Proton Exchange Membranes & Polymers

**111-2386 East Mall
Vancouver, BC Canada
V6T 1Z3**



PRODUCT INFORMATION

Ionmr designs and manufactures breakthrough advanced ion-exchange materials to enable rapid growth of the hydrogen economy. Ionmr's advanced proton exchange membranes and polymers are a breakthrough in material science with a uniquely stable hydrocarbon structure, making it the only product of its kind.

Pemion® represents a fundamental shift in the approach to proton exchange technology through its migration from perfluorosulfonic acid (PFSA) chemistry to hydrocarbon materials, providing substantially lower gas crossover and addressing PFAS-related environmental and end-of-life issues at considerably higher performance.

Pemion® enables major efficiency and performance gains, while aligning with needs of the renewable economy. It is the only environmentally friendly option on the market.

Produced on reinforcement at thicknesses competitive to leading PFSA membranes in the industry, Pemion® provides leading conductance and durability without compromise.

For use in fuel cell applications including heavy duty transport & automotive, hydrocarbon based Pemion® membrane and ionomer offers several advantages over incumbent perfluorinated materials to increase the efficiency, versatility, and lifetime of fuel cell engines, including: lower gas crossover for increases to range and the lifetimes of both membrane and catalyst; higher proton conductivity for additional gains to efficiency and power density; significantly greater temperature stability to enable many system design benefits; & a substantially easier end-of-life precious metal recovery, reducing costs & eliminating the environmental concerns specific to acidic perfluorinated compounds.

PEMION[®] REINFORCED MEMBRANES — PRE-PRODUCTION

Thickness and Basis Weight Properties

Membrane Type	Typical Thickness (µm)	Basis weight (g/m ²)
PF1-HLF8-15-X	15	18

Physical Properties ¹	MD	TD	Test Method
Tensile Strength, MPa	> 40	> 40	ASTM 638
Young's Modulus, MPa	> 600	> 550	ASTM 638
Elongation to break	> 30%	> 30%	ASTM 638

Hydrolytic Properties ²			
Water Uptake, wt%:			ASTM D570
to water soaked, 22 °C	95 - 140%		
to water soaked, 80 °C	150 - 190%		
Linear Expansion			ASTM D570
to water soaked, 22 °C	< 10%		
to water soaked, 80 °C	< 15%		
Z-Expansion			ASTM D570
to water soaked, 22 °C	< 140%		
to water soaked, 80 °C	< 190%		

Electrochemical Properties ³			
Area Resistance	< 42.5 mΩ · cm ²		
Hydrogen Crossover Current	< 2.0 mA/cm ²		Atmospheric
	< 6.0 mA/cm ²		150 kPa gauge

Measured Ex-situ Conductivity ⁴	In-plane	Through-plane
PF1-HLF8-15-X	> 90 mS/cm	> 80 mS/cm

Reference:	In-plane	Through-plane
NR211	60 ± 5 mS/cm	60 ± 5 mS/cm
15 µm Reinforced PFSA	65 ± 5 mS/cm	44 ± 4 mS/cm

Other Properties		
Specific Gravity	1.3 g/cm ³	
Maximum Processing Temperature	160 °C	
Polymer Tg	> 300 °C	

Note: These are prototype materials only intended to be used for early development activities and not intended for production items. Product information is to be used as a guide only, not as a design specification, and is subject to change at any time as part of ongoing product development. Ionomr makes no warranties, express or implied, and assumes no obligation or liability in connection with any use of this information or for results obtained in reliance thereon.

- 1 Measured at 22 °C under atmospheric condition
- 2 Measured from dried to equilibrated in de-ionized water, at the specified temperatures.
- 3 Measured in-situ via chronoamperometry at 80 °C, 100/100% RH (anode/cathode).
- 4 Membranes equilibrated in de-ionized water at 22 °C prior to measurement. Measured ex-situ using electrochemical impedance spescopy. Pemion and reference membranes measured under identical conditions.

PEMION® IONOMERS: DRY RESIN

Ionomer Type	IEC ¹ (meq/g)	EW (g/eq.)	Density (g/cm ³)	Solubility ²
Pemion PP1-HNN8-00	2.8 - 3.1	320 - 360	1.2	Alcohols and alcohol/water mixtures
Compare to:	IEC ¹ (meq/g)	EW (g/eq.)	Density (g/cm ³)	Solubility
Long side-chain PFSA	0.9 - 1.0	1000 - 1,100	2.0	Alcohols and alcohol/water mixtures
Short side-chain PFSA	1.1 - 1.3	770 - 910	2.0	Alcohols and alcohol/water mixtures
Notes				

1 IEC of polymer powder measured as-received.
 2 Refer to FM-7013 for additional information.

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Document ID	Title
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FM-6027-D	Properties of Pemion® Hydrocarbon Proton Exchange Membrane
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Revision	Prepared By	Approved By	Effective Date
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D	Omid Toussi	Andrew Belletti	March 2, 2022
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This document is reviewed to ensure its continuing relevance to the systems and process that it describes.

REVISION HISTORY:

Revision	Date	Description of Changes	Approved By
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A	March 12, 2021	Initial Draft	Ben Britton
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B	July 26, 2021	Added new picture, PF1-HLF9-15-X	Ben Britton
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C	Sept. 24, 2021	Added PF1-HLF8-15-X	Ben Britton
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D	March 2, 2022	General revisions	Andrew Belletti
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