IONOMR INNOVATIONS

# AEMION+® ELECTROLYSIS OFFERINGS

## Anion Exchange Membranes & Polymers

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



sales@ionomr.com / +1 604 628 6098 / www.ionomr.com

# PRODUCT INFORMATION

Ionomr designs and manufactures breakthrough advanced ion-exchange materials to enable rapid growth of the hydrogen economy. Ionomr Anion Exchange membranes are significantly tougher than their counterparts in industry, leading to thinner membranes, longer service life and reduced overall system costs.

They have low ionic resistance, high electrical resistance, and strong chemical stability in solutions of both high and low pH, including concentrated alkaline solutions up to 3 M at 80 °C.

Ionomr's advanced anion exchange membranes and polymers are a breakthrough in material science with a unique hydrocarbon structure and the strongest alkaline stability available, making it the only product of its kind. Aemion⁺® provides specialized solutions to OEMs with unique application challenges.

Aemion⁺® represents a fundamental shift in anion exchange technology. Through Aemion⁺®, we provide a platform to enable simultaneous performance and lifetime improvements in clean technologies while further reducing their environmental impact.

For use in electrolysis applications including AEM water electrolysis & $CO_2$ Electrolysis, hydrocarbon based Aemion⁺® membranes and polymers can be utilized in the harshest of conditions and paired with its high performance, unlocks many end use applications that were previously constrained by the membrane's integrity.

Aemion⁺® enables electrochemical systems without the need for precious metals (commonly platinum and iridium), enabling a pathway for the production of energy-efficient and low-cost green hydrogen as well as profitible carbon capture and utilization technologies.



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# AEMION+® REINFORCED MEMBRANES — PRELIMINARY

**Thickness and Reinforcement Properties**

| Membrane Type | Typical Thickness (µm) | IEC[1] (meq/g) | Reinforcement |
|---|---|---|---|
| AF2-HLE8-15-X | 15 | 2.3 - 2.6 | Non-woven Polyolefin |

| Physical Properties[2] | MD | TD | Test Method |
|---|---|---|---|
| Tensile Strength, MPa | > 60 | > 100 | ASTM 638 |
| Young's Modulus, MPa | 600 - 950 | 600 - 920 | ASTM 638 |
| Elongation to break, % | 50 - 60 | 50 - 60 | ASTM 638 |
| **Hydrolytic Properties[3]** | | | |
| Water Uptake | | | |
| to water soaked, 22 °C | < 30% | | ASTM D570 |
| to water soaked, 80 °C | < 50% | | ASTM D570 |
| Linear Expansion | | | |
| to water soaked, 22 °C | < 1.5% | | ASTM D570 |
| to water soaked, 80 °C | < 2.5% | | ASTM D570 |
| Z-Expansion | | | |
| to water soaked, 22 °C | < 35% | | ASTM D570 |
| to water soaked, 80 °C | < 80% | | ASTM D570 |
| **Electrochemical Properties** | | | |
| Area Resistance, mΩ · cm$^2$ | < 30 | | Internal[4] |
| Hydrogen Crossover Current, mA/cm$^2$ | < 2 | | 150 kPa$_g$[5] |
| Slope, mA/cm$^2$/kPa | < 0.01 | | |
| **Chemical Stability** | | | |
| Max. Recommended Condition | 3 M KOH, 80 °C | | Internal[6] |
| **Other Properties** | | | |
| Maximum Processing Temperature | 105 °C | | |
| Polymer Tg | > 300 °C | | |
| Counter-ions | $I^-$/$Cl^-$ | | |

**Notes**

1 IEC in the hydroxide ($OH^-$) counter-ion form.
2 Measured at 22 °C in atmospheric condition
3 Measured from dried to equilibrated in DI water at 22 °C
4 Measured in water electrolysis conditions at 60 °C, 1 M KOH, OCV
5 Measured in AEM fuel cell conditions with GDE configuration at 60 °C, 100% RH
6 Measured ex-situ by change in mechanical strength, conductivity & IEC after soaking electrolyte



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# AEMION+® REINFORCED MEMBRANES — PRELIMINARY

### Thickness and Reinforcement Properties

| Membrane Type | Typical Thickness (µm) | IEC[1] (meq/g) | Reinforcement |
|---|---|---|---|
| AF2-HLE8-50-X | 50 | 2.3 - 2.6 | Non-woven Polyolefin |

| Physical Properties[2] | MD | TD | Test Method |
|---|---|---|---|
| Tensile Strength, MPa | > 45 | > 50 | ASTM 638 |
| Young's Modulus, MPa | 600 - 800 | 600 - 800 | ASTM 638 |
| Elongation to break, % | 70 - 75 | 65 - 75 | ASTM 638 |
| **Hydrolytic Properties[3]** | | | |
| Water Uptake | | | |
| to water soaked, 22 °C | < 15% | | ASTM D570 |
| to water soaked, 80 °C | < 25% | | ASTM D570 |
| Linear Expansion | | | |
| to water soaked, 22 °C | < 5% | | ASTM D570 |
| to water soaked, 80 °C | < 5% | | ASTM D570 |
| Z-Expansion | | | |
| to water soaked, 22 °C | < 25% | | ASTM D570 |
| to water soaked, 80 °C | < 40% | | ASTM D570 |
| **Electrochemical Properties** | | | |
| Area Resistance, mΩ ▪ $cm^2$ | 50 - 100 | | Internal[4] |
| Hydrogen Crossover Current, mA/$cm^2$ | < 2 | | 150 $kPa_g$[5] |
| Slope, mA/$cm^2$/kPa | < 0.005 | | |
| **Chemical Stability** | | | |
| Max. Recommended Condition | 3 M KOH, 80 °C | | Internal[6] |
| **Other Properties** | | | |
| Maximum Processing Temperature | 105 °C | | |
| Polymer Tg | > 300 °C | | |
| Counter-ions | $I^-$/$Cl^-$ | | |

**Notes**

1 IEC in the hydroxide ($OH^-$) counter-ion form.
2 Measured at 22 °C in atmospheric condition
3 Measured from dried to equilibrated in DI water at 22 °C
4 Measured in water electrolysis conditions at 60 °C, 1 M KOH, OCV
5 Measured in AEM fuel cell conditions with GDE configuration at 60 °C, 100% RH
6 Measured ex-situ by change in mechanical strength, conductivity & IEC after soaking electrolyte



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# AEMION+® REINFORCED MEMBRANES — PRELIMINARY

### Thickness and Reinforcement Properties

| Membrane Type | Typical Thickness (µm) | IEC[1] (meq/g) | Reinforcement |
|---|---|---|---|
| AF2-HWP8-75-X | 75 | 2.3 - 2.6 | Woven Polyolefin |

| Physical Properties[2] | MD | TD | Test Method |
|---|---|---|---|
| Tensile Strength, MPa | > 40 | > 40 | ASTM 638 |
| Young's Modulus, MPa | 500 - 700 | 500 - 600 | ASTM 638 |
| Elongation to break, % | 30 - 40 | 30 - 40 | ASTM 638 |
| **Hydrolytic Properties[3]** | | | |
| Water Uptake | | | |
| to water soaked, 22 °C | < 45% | | ASTM D570 |
| to water soaked, 80 °C | < 50% | | ASTM D570 |
| Linear Expansion | | | |
| to water soaked, 22 °C | < 5% | | ASTM D570 |
| to water soaked, 80 °C | < 5% | | ASTM D570 |
| Z-Expansion | | | |
| to water soaked, 22 °C | < 10% | | ASTM D570 |
| to water soaked, 80 °C | < 15% | | ASTM D570 |
| **Electrochemical Properties** | | | |
| Area Resistance, mΩ · $cm^2$ | < 150 | | Internal[4] |
| Hydrogen Crossover Current, mA/$cm^2$ | < 1.5 | | 150 $kPa_g$[5] |
| Slope, mA/$cm^2$/kPa | < 0.006 | | |
| **Chemical Stability** | | | |
| Max. Recommended Condition | 3 M KOH, 80 °C | | Internal[6] |
| **Other Properties** | | | |
| Maximum Processing Temperature | 105 °C | | |
| Polymer Tg | > 300 °C | | |
| Counter-ions | $I^-$/$Cl^-$ | | |

**Notes**

1 IEC in the hydroxide ($OH^-$) counter-ion form.
2 Measured at 22 °C in atmospheric condition
3 Measured from dried to equilibrated in DI water at 22 °C
4 Measured in water electrolysis conditions at 60 °C, 1 M KOH, OCV
5 Measured in AEM fuel cell conditions with GDE configuration at 60 °C, 100% RH
6 Measured ex-situ by change in mechanical strength, conductivity & IEC after soaking electrolyte



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# AEMION+® REINFORCED MEMBRANES — PRELIMINARY

### Thickness and Reinforcement Properties

| Membrane Type | Typical Thickness (µm) | IEC[1] (meq/g) | Reinforcement |
|---|---|---|---|
| AF2-HWP8-100-X | 100 | 2.3 - 2.6 | Woven Polyolefin |

| Physical Properties[2] | MD | TD | Test Method |
|---|---|---|---|
| Tensile Strength, MPa | > 40 | > 40 | ASTM 638 |
| Young's Modulus, MPa | 600 - 1000 | 600 - 1000 | ASTM 638 |
| Elongation to break, % | 30 - 42 | 30 - 52 | ASTM 638 |
| **Hydrolytic Properties[3]** | | | |
| Water Uptake | | | |
| to water soaked, 22 °C | < 40% | | ASTM D570 |
| to water soaked, 80 °C | < 50% | | ASTM D570 |
| Linear Expansion | | | |
| to water soaked, 22 °C | < 5% | | ASTM D570 |
| to water soaked, 80 °C | < 5% | | ASTM D570 |
| Z-Expansion | | | |
| to water soaked, 22 °C | < 15% | | ASTM D570 |
| to water soaked, 80 °C | < 20% | | ASTM D570 |
| **Electrochemical Properties** | | | |
| Area Resistance, mΩ · $cm^2$ | < 150 | | Internal[4] |
| Hydrogen Crossover Current, mA/$cm^2$ | < 1.5 | | 150 $kPa_g$[5] |
| Slope, mA/$cm^2$/kPa | < 0.005 | | |
| **Chemical Stability** | | | |
| Max. Recommended Condition | 3 M KOH, 80 °C | | Internal[6] |
| **Other Properties** | | | |
| Maximum Processing Temperature | 105 °C | | |
| Polymer Tg | > 300 °C | | |
| Counter-ions | $I^-$/$Cl^-$ | | |

**Notes**

1 IEC in the hydroxide ($OH^-$) counter-ion form.
2 Measured at 22 °C in atmospheric condition
3 Measured from dried to equilibrated in DI water at 22 °C
4 Measured in water electrolysis conditions at 60 °C, 1 M KOH, OCV
5 Measured in AEM fuel cell conditions with GDE configuration at 60 °C, 100% RH
6 Measured ex-situ by change in mechanical strength, conductivity & IEC after soaking electrolyte



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# AEMION+® IONOMERS: DRY RESIN

| Ionomer Type | IEC[1] (meq/g) | Conductivity $Cl^-/I^-$ (mS/cm) | Water Uptake[2] $OH^-$ (%) | Water Uptake[2] $Cl^-/I^-$ (%) |
|---|---|---|---|---|
| AP2-HNN8-00 | 2.3 - 2.6 | 8 - 11 | 95 - 100 | 20 - 60 |
| AP2-HNN5-00 | 1.4 - 1.7 | 2 - 4 | 35 - 50 | 20 - 45 |
| AP2-HNN2-00 | 0.5 - 0.6 | 1.3 - 2.5 | 13 - 15 | 10 - 20 |

**Notes**

1 IEC in the hydroxide ($OH^-$) counter-ion form.
2 Approximate swelling properties when cast into membrane form at 25 - 50 µm

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, subject to change at any time.

| Document ID | Title |
|---|---|
| FM-6028-A | Properties of Aemion+™ Water Electrolysis Membranes |

| Revision | Prepared By | Approved By | Effective Date |
|---|---|---|---|
| A | Omid Toussi | Ben Britton | March 30, 2021 |

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 |
|---|---|---|---|
| A | March 30, 2021 | Initial Draft | Ben Britton |

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, subject to change at any time.



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