



AEMION⁺® APPLICATION NOTE: **Handling, Dispersion, and Ink Formulation**

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ANION EXCHANGE MEMBRANES: HANDLING, STORAGE AND PRE-TREATMENT INSTRUCTIONS

GENERAL

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 2M at 100 °C and up to 6 M at lower temperatures.

HANDLING AND STORAGE

Store, handle and process the membrane in a clean, dust-free environment. Only use new and sharp blades when cutting the membrane for best results. Gloves should be worn when handling the membrane. The membrane should be handled with care: do not puncture, crease or tear the membrane. All surfaces that come in contact with the membrane during handling, inspection, treatment, storage, and installation should be smooth and clean.

Long term storage in the dry form is best done in a sealed container with minimum exposure to heat and light. Wet storage may be done in containers containing aqueous electrolytes (e.g. NaCl, KOH).

PRE-TREATMENT

Membranes are delivered in the dry, iodide form. Depending on specific applications and cell designs, assembly may be possible in either the dry form (without pre-treatment), or the wet form (with pre-treatment). For optimal results, pre-treat the membranes by soaking them in the electrolyte that will be used for a period of at least 24 hours at room temperature, refreshing the electrolyte at least once. For hydroxide transport applications such as water electrolysis or AEM fuel cells, it is recommended to soak the membrane or MEA in 1 M KOH for a minimum of 24 hours at room temperature and refreshing the electrolyte at least once. For fuel cell applications, soaking for at least 24 hours and 36-48 hours is recommended. Exchange into KOH first may be beneficial for other ion-exchanges such as into the sulfate form. It is preferable that the membrane then be mounted wet, as differential stresses due to dimensional changes may occur upon drying.

Minimize air exposure as carbonation will impact initial performance and operation for 24-72 hours may be necessary to achieve conditioned performance. **AFTER EXCHANGE to hydroxide form the membranes should NEVER BE EXPOSED TO DI WATER**, Any neutral rinsing should be performed in an aqueous electrolyte of similar concentration (i.e 1-3M NaCl or KCl)

If there are any concerns about storage, chemical stability, or pre-treatment, please contact us for further information.



REMOVAL OF THE MEMBRANES FROM THE BACKING LAYER:

Primary method

1. With clean gloved hands, hold the membrane on its backing layer.
2. Take your thumb or a finger and rub against the corner edge of the membrane to produce separation from the backing layer.
3. Once corner separation from the backing layer is achieved, carefully and gently, begin to pull the membrane from the backing layer whilst holding the membrane down on a clean dry surface.
4. As the backing layer is released, support the membrane as you continuously remove it from the backing layer until all of the membrane has been removed.

FOR COATING AEMION+™ MEMBRANE AFTER REMOVING FROM THE BACKING LAYER

Ensure that the membrane remains flat.

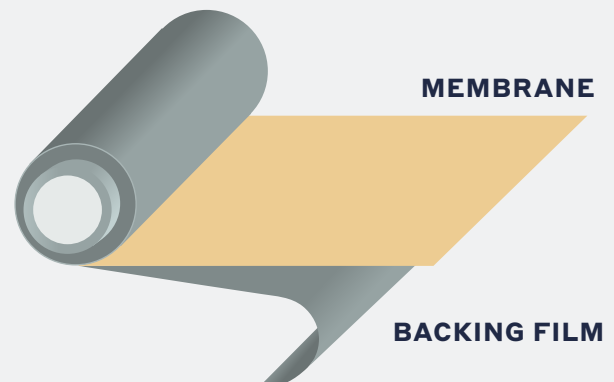
A Powder Coating Masking Tape is recommended (i.e. McMaster-Carr <https://www.mcmaster.com/7630A24/>) to overlap the edges of the membrane prior to coating procedures to stabilize the membrane in place. This will help maintain the membrane positioning, and eliminate stress lines that may develop. Use caution when removing tape from membrane after the coating process as tears may occur. Cutting off taped area is an alternative.

Use caution to remove tape from membrane after the coating process.

Secondary method

1. With clean gloves, wet a portion of the membrane/backing layer edge with de-ionized water; this should aid in separation of the membrane from the backing layer. Repeat the steps in the primary method
2. If the membrane does not separate upon initial wetting, spritz a small amount of water area close to the edge of the membrane and repeat the primary method.

Roll Unwind Orientation (Base Film Facing Out)



ANION EXCHANGE IONOMERS: DISPERSION AND INK FORMULATION

DISPERSION AND INK FORMULATION

The following is a starting point for preparing catalyst inks based on an ink formulation designed for fuel cell catalyst layers. Please note that different ionomer content may be required depending on the application. Similarly, depending on the application and performance requirements, further optimization may be required, such as solvent composition and weight percent of solids in solution.

1. Calculate the mass of polymer, catalyst powder, and solvents required for electrode composition. As a guideline, the final ionomer to catalyst ratio should be around 10 to 25 wt%. This is heavily application dependent. Adapting existing ink formulation based on polymers of other densities based on vol% is suggested for an initial approximation. The density of Aemion⁺ is ~1.2 g/mL, so an ink based on 30 wt% of a ~2.0 g/mL polymer would be approximately equivalent to 18 wt% Aemion⁺. It is recommended that the solvent ratio is 1:1 organic solvent or solvent mix to water, e.g. 1:1 MeOH:water. The primary alcohol can be adjusted after the polymer is dissolved in step 2. The volume of solvents required should be dictated by a final weight percent of total solids (catalyst powder + ionomer), with 1-2 wt% suggested for electrode application by spray-coating. One method of controlling drying characteristics (e.g. membrane swelling causing wrinkled catalyst layers, catalyst layer porosity, etc.) is to alter the alcohol ratio; it is strongly inadvisable to increase this ratio above 3:1

2. On a stir plate (with magnetic stirring capabilities), prepare a 3-5 wt% solution of Aemion+ and suitable low-boiling alcohol mixture from below (e.g. methanol/acetone) to dissolve the polymer. If particles are noted, pass the ionomer through a glass fiber filter to eliminate any contaminants. Reserve about 5 mL of the chosen alcohol to capture concentrated ionomer coating the glassware after dropwise addition (mentioned later).

Disclaimer

Ionomr Innovations Inc. is not responsible for any damages or loss of materials when preparing catalyst inks. Always use caution when mixing any finely divided metal catalyst particles with flammable solvents as spontaneous combustion may occur. Use proper containment procedures and wear personal protective equipment at all times.

3. Preferably in a narrow-necked glass bottle and on a stir plate capable of magnetic stirring, add the catalyst (such as Pt/C) powder followed by a stir bar and all the calculated water. Stir gently (e.g. 100 RPM) until catalyst powder is fully wetted and dispersed. Increase stir rate until a vortex begins to form but before cavitation (e.g. 400-600 RPM, heavily dependent on ink volume and stir bar size)

4. Slowly pour in the calculated alcohol, apart from the 5 mL reserve and that contained in the ionomer solution. Maintain vigorous stirring and add the alcohol/ionomer solution dropwise, visually ensuring surface accumulation of polymer is kept to a minimum. Occasionally swish to integrate catalyst particles that accumulate at the ink-bottle interface. Use the remaining 5 mL of alcohol to rinse the ionomer glassware (i.e. capture the residual polymer so calculated values for ionomer are realized) and dislodge any remaining catalyst powder from the sides of the ink bottle. Stir at moderate rate (e.g. 300 RPM) until use; a minimum of four hours is recommended. Treatment in a low-power sonication bath for 15-30 minutes after an initial 30-60 minutes of stirring may help homogeneity.



LIST OF SUITABLE SOLVENTS FOR HIGH IEC AEMION⁺® POLYMER AP2-HNN8-00

| Solvent Type | Comments | Recommended Solubility wt% |
|--------------------|---|----------------------------|
| Methanol / Acetone | 50:50 (v/v) mixture. Recommended low-boiling solvent for spray coating, electrode fabrication, etc. | 1% – 10% |
| Ethanol / Acetone | 80:20 (v/v) mixture | 1% - 6% |
| DMSO | Recommended high boiling point solvent to achieve high viscosity, can cause complications with gas permeability | 1% - 10% |
| NMP, DMF | High boiling point solvents, can cause complications with gas permeability | 1% - 10% |

LIST OF SUITABLE SOLVENTS FOR LOW IEC AEMION⁺® POLYMER AP2-HNN2-00

| Solvent Type | Comments | Recommended Solubility wt% |
|--------------------|---|----------------------------|
| Methanol / Acetone | 50:50 (v/v) mixture. Recommended low-boiling solvent for spray coating, electrode fabrication, etc. | 1% – 10% |
| Ethanol / Acetone | 80:20 (v/v) mixture | 1% - 6% |
| DMSO | Recommended high boiling point solvent to achieve high viscosity, can cause complications with gas permeability | 1% - 10% |
| NMP, DMF | High boiling point solvents, can cause complications with gas permeability | 1% - 10% |

Note: To achieve solubility at mid to high wt% range, may require appropriate heating and stirring for up to 48 hours. Sonication may speed-up this process but is not recommended beyond ~30 minutes in a sonication bath

DOCUMENT CHANGE HISTORY

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|-------------|--|
| FM-7012-E | Aemion+® Application Note: Handling, Dispersion, and Ink Formulation |

| Revision | Prepared By | Approved By | Effective Date |
|----------|-------------|-------------|----------------|
| E | Omid Toussi | Ben Britton | July 26, 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 | Jan. 27, 2020 | Initial Draft | Ben Britton |
| B | Sep. 17, 2020 | Updated backer removal, ink formulation, solvents | Ben Britton |
| C | Nov. 16, 2020 | Additional solvents | Ben Britton |
| D | Feb. 26, 2021 | Document design and name updated | Ben Britton |
| E | July 26, 2021 | Conditioning step updated | Ben Britton |