IONOMR INNOVATIONS

PEMION® APPLICATION NOTE:

Handling, Dispersion, and Ink Formulation

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Document ID: FM-7013-D

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

GENERAL

Ionomr Proton Exchange membranes are the only non-fluorinated ion exchange membranes with the required chemical stability for operation in fuel cells. They have low ionic resistance, ultra-low hydrogen crossover, high electrical resistance, and offer strong chemical durability demonstrating over 1000 hours of lifetime at Open Circuit Voltage (OCV) when subjected to the Department of Energy's chemical durability accelerated stress test.

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 water or aqueous electrolytes (e.g. NaCl, KOH).

PRE-TREATMENT

Membranes are typically delivered dry, in the acid (H^+) form. Depending on specific applications and cell designs, assembly may be possible in the dry form (without pre-treatment), or in the wet form (with pre-treatment). For optimal results, it is recommended to use the membranes dry, as produced, and condition within the electrochemical cell. If you wish to pre-treat/pre-swell the membranes, this can be completed by soaking them in a strong acid (i.e. 6 M HCl or H_2SO_4) for a period of at least 12 hours at room temperature

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.

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, apply a small amount of water across an area close to the edge of the membrane and repeat the primary method. Do not subsequently use the wetted portion of the membrane in the device active area.

FOR COATING PEMION® MEMBRANE AFTER REMOVING FROM THE BACKING LAYER

Ensure that the membrane remains flat.

A Powder Coating Masking Tape is recommended (e.g. 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 to remove tape from membrane after the coating process.

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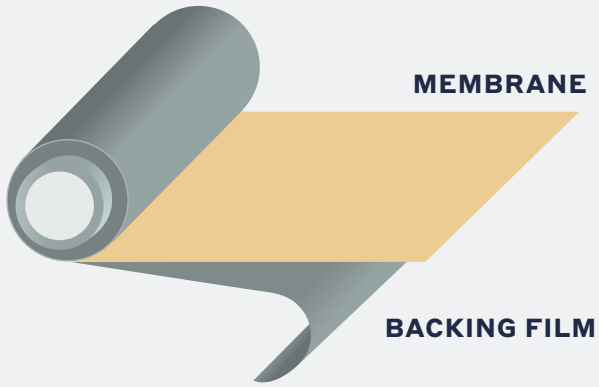
Roll Unwind Orientation
(Base Film Facing Out)



PROTON 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 and operational conditions required. 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 Pemion 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% Pemion. It is recommended that the solvent ratio is 1:1 alcohol to water, e.g. 1:1 IPA: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 Pemion and suitable solvent or solvent mixture from below (e.g. methanol) 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).

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.

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.

LIST OF SUITABLE SOLVENTS FOR PEMION™ POLYMER PP1-HNN9-00

Solvent Type	Comments	Solubility wt%
Methanol	Low-boiling solvent for spray coating, electrode fabrication, etc.	**1% – 15%**
Reagent Alcohol (85% EtOHl/ 5%MeOH/ 5%iso-propanol)	Low-boiling solvent for spray coating, electrode fabrication, etc.	**1% - 16%**
Ethanol	Low-boiling solvent for spray coating, electrode fabrication, etc.	**1% - 7%**
Ethanol/IPA (50:50 by weight)	High boiling point solvents, can cause complications with gas permeability	**1% - 5%**
IPA/water (50:50 by volume)	Low-boiling solvent for spray coating, electrode fabrication, etc	**1% – 10%**
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

Document ID	Document ID		
FM-7005-D	Pemion® Application Note: Handling, Dispersion, and Ink		
Revision	**Prepared By**	**Approved By**	**Effective Date**
D	Omid Toussi		

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	Oct. 16, 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	