Properties of Melt-Extruded vs. Solution-Cast Proton Exchange Membranes Based on PFSA Nanocomposites

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Hybrid membranes are commonly generated by *in situ* precipitation of the inorganic material within an ionomer preformed membrane or in a polymer solution (1). Melt-extruded proton exchange membranes (PEMs) are a new class of membrane materials with different morphologies and desirable properties for fuel cell technology.

Through collaboration between NRC (Canada) and CSIC (Spain), this work examines the effect of the processing conditions on the properties of series of hybrid PEM materials. Several nanocomposite PEMs have been prepared using different families of functional inorganic fillers and two different processes, solution-casting and melt-extrusion. Functional fillers were kindly supplied from Dr. G. Diaz from IMI-NRC and Prof. F. Sanchez from IQOG-CSIC. The work related to their synthesis will be presented in another paper.

For solvent-cast hybrid membranes, Nafion solution (5%) was used, while for melt-processing, an extrusion grade of Nafion in the sulfonyl fluoride form was used to prevent sulfonic acid degradation during the extrusion process. The former hybrid membranes were converted to the acid form prior to characterization.

To obtain an understanding of the relationship between morphology and properties, samples have been fully characterized in terms of their structure (TEM, XRD) as well as thermal (DSC, TGA), mechanical (DMTA) and electrochemical properties (IEC, WU, conductivity measurement at controlled T and RH, fuel cell testing). Figure 1 presents high resolution TEM micrographs obtained for solution-cast and melt-extruded Nafion membranes. Ordered ionic domains agglomerated in spheres ranging from 3 to 10 nm diameter can be observed for solution cast membranes, while more interconnected and uniform hydrophilic domains (4 to 6 nm) are observed in the case of melt-extruded sample.

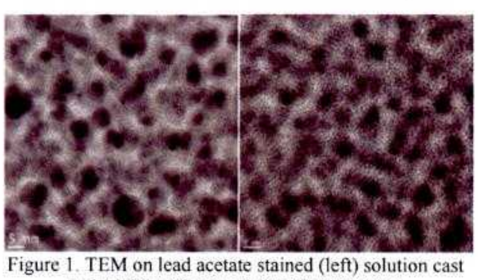

Figure 1. TEM on lead acetate stained (left) solution cast and (right) melt extruded Nafion samples.

These differences in morphology will certainly have an impact on the properties of PEMs. Figure 2 shows the preliminary conductivity results obtained for two series of hybrid PEMs prepared by solution casting and melt-extrusion. It shows that at high levels of hydration, solution cast membranes have in general higher conductivity than extruded samples, while at high temperature and reduced relative humidity conditions, the reverse tendency is observed.

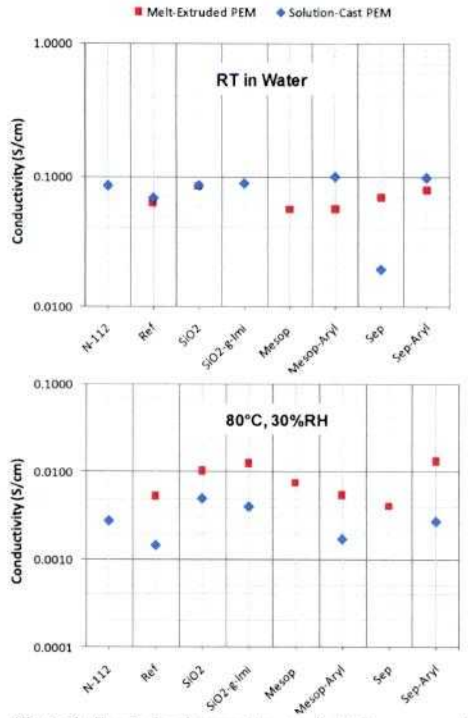

Figure 2. *Ex-situ* in-plane proton conductivity measured for series of solvent-cast and melt extruded PEMs at RT/in water and at 80°C/30%RH.

Acknowledgments

The authors thank Dr. G. Diaz from IMI-NRC and Prof. F. Sanchez from IQOG-CSIC for providing functional fillers, and the NRC-CSIC Collaborative Research Program for the financial support.

References

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