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Fuel cell performance of poly(arylene ether nitrile)s containing pendant sulfonic acid groups under reduced RH conditions

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New polymer electrolyte membranes (PEMs) that have high proton conductivity, low reactant permeability and reduced water uptake are required for the fuel cell applications. In the last decade, sulfonated poly(arylene ether)s are thought to be one of the promising routes to high performance PEMs because of their well-known oxidative and hydrolytic stability in the fuel cell environment.[1] Recently, a poly(arylene ether nitrile)s (PAEN) containing pendant phenyl sulfonic acids were synthesized.[2] The PAEN was prepared from difluorobenzonitrile (DFBN) by polycondensation with 2-phenylhydroquinone (PHQ) by conventional aromatic nucleophilic substitution reactions. The sulfonic acid groups were introduced by mild post-sulfonation exclusively on the *para*-position of the pendant phenyl ring in PHQ. The membrane properties of the resulting sulfonated copolymer (sPAEN) were characterized for fuel cell applications.

The sPAEN having a degree of sulfonation (DS) of 1.0 had high ion exchange capacities (IEC_v(wet) (volume-based, wet state)) of 2.55 meq./cm^3, high proton conductivities of 140.1 mS/cm at 80^{o}C, and acceptable volume-based water uptake of 51.9 vol% at 80^{o}C. The data points of these copolymer membranes are located in the upper left-hand corner in the trade-off plot of alternative hydrocarbon polyelectrolyte membranes (PEM) for the relationship between proton conductivity versus water uptake (weight based or volume based), i.e., high proton conductivity and low water uptake. Membrane-electrode assemblies (MEAs) using the copolymers and Nafion-bonded electrodes were fabricated by newly developed MEA fabrication method.[3] Fuel cell performance of the MEAs and Nafion control MEA were evaluated under reduced RH conditions. Detail description of the new MEA fabrication method, initial and long-term fuel cell performance will be discussed at the meeting. These highly conductive copolymers have potential to use for fuel cell under reduced RH operating conditions.

References

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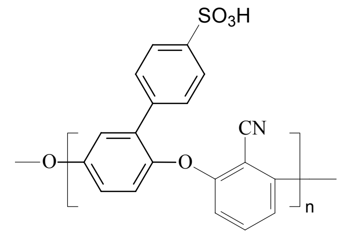

sPAEN

Scheme 1. Structure of sulfonated poly(arylene ether nitrile) copolymers containing pendant sulfonic acid group

Table 1. Properties of the membranes

Sample	[a]Density (g/cm^3)	[b]IEC_w (meq./g)	[c]IEC_v (meq./cm^3)		[d]Water uptake(wt%)	[e]σ (mS/cm)
			dry	wet		
sPAEN	1.31	2.71	3.55	2.55	39.6	140
Nafion	1.98	0.9	1.78	1.29	28.6	125

[a] based on dry state, [b] based on weight of dry membrane, [c] based on volume of dry and/or wet membranes (IEC_v (wet) = IEC_v(dry)/(1+0.01 WU)), [d]WU (mass %) = (W_{wet} −W_{dry})/W_{dry} x 100, (W_{wet} and W_{dry} are the weights of the wet and dry membranes, respectively; δ_w is the density of water (lg/cm^3), and δ_m is the membrane density in the dry state.) at 80 ^{o}C, [e] at 80 ^{o}C