Application of Sulfonated Diels-Alder Polyphenylenes in Hydrogen Based PEM Fuel Cells.

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Introduction:

The limitations of perfluoronated PEMs (i.e. Nafion) such as, low performance at temperatures above 80 ^{o}C, high fuel permeation in DMFCs, cost and environmental processing issues have spurred the search for a cheaper and efficient alternative.[1,2,3]

Polyphenylenes represent a promising class of thermoplastics that show potential as a PEM fuel cell material. Moreover, polyphenylene synthesized though Diels Alder (DA) polymerization has advantages of thermal stability, organic solubility and mechanically robust films.[4,5,6]

Until now DA polyphenylenes have not been applied towards polyelectrolyte usage, even though this class of polymer exhibits promising physical properties such as, easily tunable backbone/lateral groups and the potential of incorporating three acidic functional groups per repeat unit compared to one in most poly(arylene) systems. We report here the physical properties and preliminary hydrogen fuel cell performance data of this class of polymer.

Experimental:

Membrane Preparation. 0.5 g of sulfonated DA polymer was casted on a clean glass plate as the sodium salt form in 10 mL of NMP. The cast was left to evaporate at 80 ^{o}C under a constant flow of N_2 for 12 hrs. The film was then dried at 100 ^{o}C under vacuum for 24 hrs and acidified (soak in 2M H_2SO_4 for 24 hrs)

Ion-Exchange Capacity. 0.2 g of acidified polymer was dried and weighed. The sample was then treated with 10 mL of 0.1 M NaOH and stirred for 24 hrs. The sample was then filtered and titrated against 0.01 M HCl.

Water Uptake. The acidified films were immersed in DI water for 24 hrs. at 25 ^{o}C. They were then blotted dry and weighed (W_s). The films were then dried and weighted until a constant weight was achieved (W_d). Water uptake was calculated by:

Water uptake =[$W_s - W_d / W_d$] x 100%

Proton Conductivity. The conductivities were determined in fully hydrated films by AC impedance spectroscopy over a frequency range of $1x10^3$ Hz to $1x10^6$ Hz using a Solartron 1260 gain phase analyzer.

Fuel Cell Testing. Polarization curves of the membranes were taken on a Fuel Cell Technologies instrument using UP H_2 and O_2 as reactant gases.

Results and Discussion.

Sulfonated DA polymers were readily cast into films from NMP. These films were robust and showed no forms of brittleness even when dried.

The films displayed proton conductives ranging from 10-80 mS/cm while still maintaining mechanical stability (swelling under 50%).

IEC	Swelling	Conductivity (mS/cm)
0.92	10%	10
1.03	15%	19
1.51	27%	29
1.70	35%	49
2.25	50%	62

Fuel cell performance data indicted that the sulfonated DA polymers could obtain high power levels and current densities of 342 mW/cm^2 at 800 mA/cm^2.

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