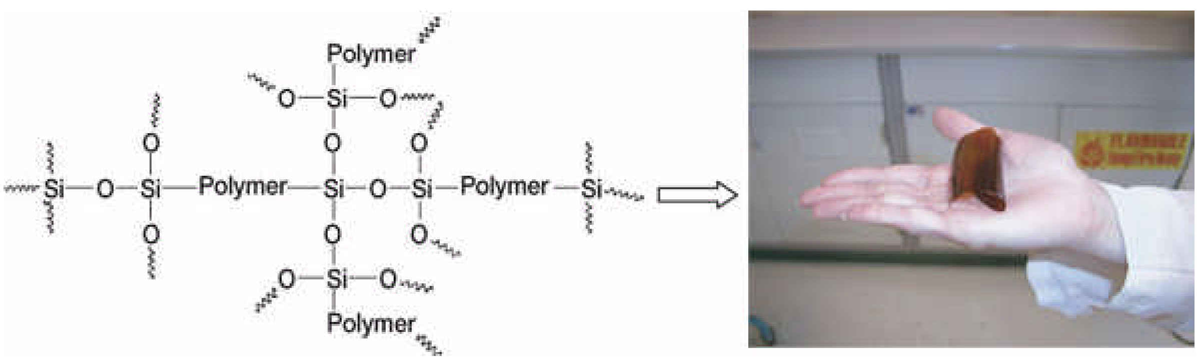
New High-Temperature Membranes Developed for Proton Exchange Membrane Fuel Cells

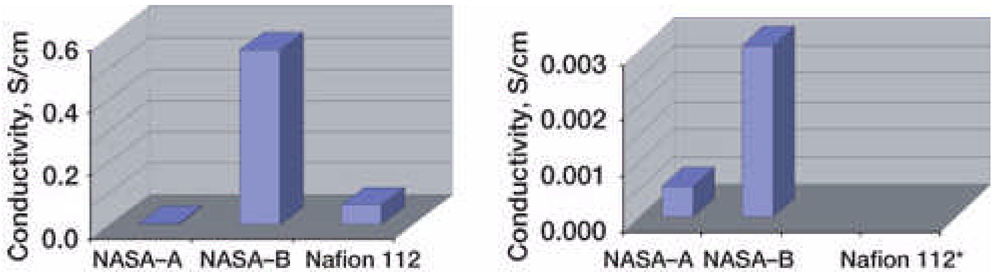
Fuel cells are receiving a considerable amount of attention for potential use in a variety of areas, including the automotive industry, commercial power generation, and personal electronics. Research at the NASA Glenn Research Center has focused on the development of fuel cells for use in aerospace power systems for aircraft, unmanned air vehicles, and space transportation systems. These applications require fuel cells with higher power densities and better durability than what is required for nonaerospace uses. In addition, membrane cost is a concern for any fuel cell application. The most widely used membrane materials for proton exchange membrane (PEM) fuel cells are based on sulfonated perfluorinated polyethers, typically Nafion 117, Flemion, or Aciplex. However, these polymers are costly and do not function well at temperatures above 80 °C. At higher temperatures, conventional membrane materials dry out and lose their ability to conduct protons, essential for the operation of the fuel cell. Increasing the operating temperature of PEM fuel cells from 80 to 120 °C would significantly increase their power densities and enhance their durability by reducing the susceptibility of the electrode catalysts to carbon monoxide poisoning. Glenn's Polymers Branch has focused on developing new, low-cost membranes that can operate at these higher temperatures.



ORMOSIL polymer used in high-temperature proton exchange fuel cell. Left: structure. Right: polymer membrane of fuel cell.

A new series of organically modified siloxane (ORMOSIL) polymers were synthesized for use as membrane materials in a high-temperature PEM fuel cell (see the preceding figure). These polymers have an organic portion that can allow protons to transport through the polymer film and a cross-linked silica network that gives the polymers dimensional stability. These flexible xerogel polymer films are thermally stable, with decomposition onset as high as 380 °C (see the preceding figure).

Two types of proton-conducting ORMOSIL films have been produced: (1) NASA-A, which can coordinate many highly acid inorganic salts that facilitate proton conduction and (2) NASA-B, which has been produced and which incorporates strongly acidic (proton donating) functional groups into the polymer backbone. Both of these polymer films have demonstrated significantly higher proton conductivity than Nafion at elevated temperatures and low relative humidities (see the bar charts). An added advantage is that these polymers are very inexpensive to produce because their starting materials are commodity chemicals that are commercially available in large volumes.



*Conductivity data. Left: At 100 °C and 47-percent relative humidity. Right: At 120 °C and 25-percent relative humidity. (*Below detection limit.)*

Find out more about this research:
http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html

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