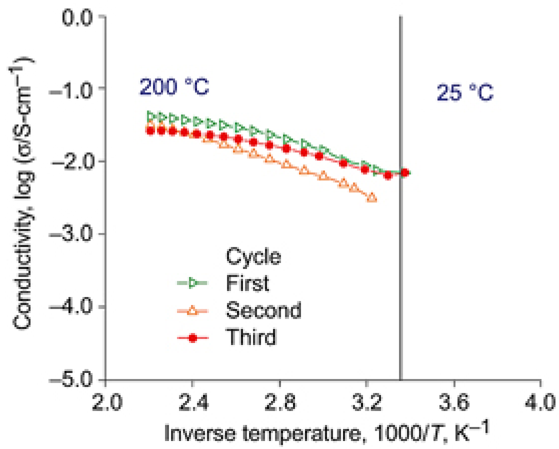
Nonhumidified High-Temperature Membranes Developed for Proton Exchange Membrane Fuel Cells

Fuel cells are being considered for a wide variety of aerospace applications. One of the most versatile types of fuel cells is the proton-exchange-membrane (PEM) fuel cell. PEM fuel cells can be easily scaled to meet the power and space requirements of a specific application. For example, small 100-W PEM fuel cells are being considered for personal power for extravehicular activity suit applications, whereas larger PEM fuel cells are being designed for primary power in airplanes and in uninhabited air vehicles.

Typically, PEM fuel cells operate at temperatures up to 80 °C. To increase the efficiency and power density of the fuel cell system, researchers are pursuing methods to extend the operating temperature of the PEM fuel cell to 180 °C. The most widely used membranes in PEM fuel cells are Nafion 112 and Nafion 117--sulfonated perfluorinated polyethers that were developed by DuPont. In addition to their relatively high cost, the properties of these membranes limit their use in a PEM fuel cell to around 80 °C. The proton conductivity of Nafion membranes significantly decreases above 80 °C because the membrane dehydrates. The useful operating range of Nafion-based PEM fuel cells can be extended to over 100 °C if ancillary equipment, such as compressors and humidifiers, is added to maintain moisture levels within the membrane. However, the addition of these components reduces the power density and increases the complexity of the fuel cell system.

Researchers at the NASA Glenn Research Center have developed a new type of membrane material (GRC AeroM) for use in PEM fuel cells that has excellent proton conductivity at temperatures as high as 180 °C. The unique feature of these membranes is that they do not require any external humidification to operate. The membranes were designed to take advantage of novel microencapsulation methods and advanced membrane designs being pursued by Glenn’s Polymer Branch. The resulting membranes have demonstrated excellent reproducible and stable ionic conductivity even after 24 hr of cycling the membrane temperature from 23 to 180 °C (see the graph). Plans for future work focus on constructing membrane electrode assemblies with these materials and testing them in a single-cell hydrogen-air fuel cell.



Conductivity data for GRC AeroM as function of temperature. Multiple temperature cycles shown.

Long description of figure. Graph of conductivity [log (σ/S-cm^{-1}) versus inverse temperature, 1000/T, in K^{-1} for the first, second, and third cycles.

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

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