High-Temperature Proton Exchange Membrane Fuel Cells as Advanced Soldier Portable Power

Assembly of HPW/mesoporous silica composite membranes by (a) vacuum impregnation method and (b) conventional impregnation method.

TEM micrographs of 30wt% HPW/mesoporous silica electrolyte by vacuum impregnation method, viewing along the pore axis.Insets are the high resolution images.
Polarization curves and power density of a cell with a 30wt%HPW/meso-silica electrolyte membrane in methanol/O2 at different temperatures.

Test set-up for high temperature direct methanol fuel cells (HT-DMFC).

There has been persistent demand for compact, lightweight and long-life power sources in the power range of 25-150 W for meeting the field needs of the soldier. The future-day soldiers will be outfitted with high-tech electronics that significantly increase awareness of the combat environment. Radios, nightvision devices, portable computers and personal cooling systems are some of examples of power-hungry electronic devices for the future-day soldiers. Conventional batteries including lithium-ion technology are too bulky and have limited service life. Thus, fuel cells based on direct consumption of low cost and more readily available liquid fuels without the need for storage will be more compact, lightweight, long-lasting and more competitive than conventional battery technologies. One of the key challenges in such compact fuel cells is to
operate fuel cells at elevated high temperatures of 100-200°C. The operation of fuel cells at temperatures higher than 100°C is considered to provide many advantages, such as the elimination of CO poisoning of platinum electrocatalyst, faster electrode reaction kinetics, simplified water and heat management, higher energy efficiency, and reduced usage of precious Pt and Pt alloy catalysts.

The objective of the project is to develop high temperature proton exchange membrane fuel cells (HT-PEMFCs) based on a novel mesoporous inorganic materials. Mesoporous inorganic materials have a pore size range of 2-50 nm and are characterized by high specific surface area, nano-sized channels or frameworks with an ordered interconnected internal structure, and high structural stability that allow their potential applications as proton exchange membranes at elevated temperatures. On the other hand, heteropoly acids (HPAs) are known superionic conductors in their fully hydrated states. 12-tungstophosphiric acid (H3PW12O40, HPW) has the strongest acidity among the Keggin-type HPAs. A novel and new synthesis method will be developed to dope the mesoporous silica with the proton conductive HPW. The HT-PEMFCs based on HPW/mesoporous silica membranes will be fabricated and demonstrated for the liquid fuels such as methanol and ethanol at elevated temperatures of 100-200°C. The target of the project is to fabricate and demonstrate a 20-30W power stack operating at 100-200°C with liquid fuels.