V.B.24 New Proton Conductive Composite Materials with Co-Continuous Phases Using Functionalized and Crosslinkable TFE/VDF Fluoropolymers

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Objectives

The main objective of the project is to develop a new membrane material based on the combination of inorganic proton conductors with a functionalized and cross-linkable Teflon-type polymer. The targeted properties of the new material are

- Proton conductivity of ~0.1 S/cm at 120°C and relative humidity (RH) 50% and ~0.07 S/cm at 25°C and RH 80%.
- Mechanical and chemical stability over the temperature range -30 to 120°C.
- Low H_2 or O_2 gas permeability.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section (3.4.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(B) Cost

(D) Thermal, Air and Water Management

Technical Targets

This research effort will contribute to the development of the hydrogen economy, and the positive outcomes will promote cleaner and more efficient power generation for automotive and stationary applications. The main target of the proposed work is to develop a new alternative membrane material that can be used in a conventional proton exchange membrane fuel cell over extended ranges of temperature and RH. The new membrane materials will efficiently conduct protons at temperatures up to 120°C and relative humidity down to 25%.

Approach

We use an innovative approach in which a highly hydrophilic inorganic particulate material with structural or surface proton conductivity serves as major membrane component with continuous phase, and the end-chain functionalized Teflon-based polymer serves as a matrix providing membrane integrity and continuity of charge transfer between the particles. The proposed polymer, a low molecular weight telechelic Teflon-based polymer with vinylidene fluoride, contains inorganic functional groups, which contribute to overall hydrophilicity of the material and provide linking between the polymeric and inorganic phases. The synthesis procedure of such a composite membrane takes into account the interaction between the functional groups of the polymer, the charged surface sites on the inorganic particle surface, and the surface electrochemistry of both components. The array of the inorganic proton conductors includes layered and 3-dimensional hydrogen phosphates, mesoporous oxides, and porous titanosilicates. The aforesaid inorganic materials are highly advantageous for high temperature and low RH applications due to high hydrophilicity and ability to strongly retain water in the electrical double layer and to conduct protons through the surface paths. Both the inorganic solids and the polymer are very inert and thermally stable over a wide temperature range.

Accomplishments

This project has just been initiated and has no progress to report at this time.