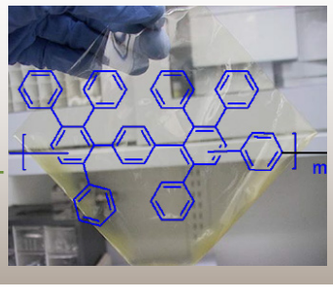
Poly (phenylene)-based Hydrocarbon Membrane Separators

Hydrocarbon Membranes for Energy & Electrochemical Systems



Diels-Alder poly(phenylene) membrane

With low projected manufacturing costs, high ion conductivities, reduced cross-over, chemical and thermal stability in both acidic and alkaline environments, the Sandia membrane technology is positioned to lower the cost of many energy-water systems.

Poly (phenylene)-based Hydrocarbon Membrane Separators

With a larger component of our electricity generation coming from intermittent and variable sources, stationary energy storage and local power generation will be essential for continued growth of the renewable energy markets and stabilization of the electricity grid. In the transportation sector, fuel cell vehicles are emerging as a strong contender to electric vehicles due to shorter refueling times and a longer driving range.

Poly (phenylene)-based hydrocarbon membrane separators, developed at Sandia National Laboratories, are showing exceptional performance in real-world applications tests by system customers and partner research institutions. Polymer membranes play a crucial function in many energy and water technologies, including energy storage, water electrolysis and purification, and stationary and transportation power systems. The membranes are tailored to allow conduction of specific ionic species between the negative and positive electrodes in an electrochemical system. For example, polymer membranes can be optimized for transport of protons (H+) or hydroxyl ions (OH-), depending on the acidic or alkaline environment of the energy-water system.

Poly (phenylene) Backbone

An important advantage of the Sandia technology is that the poly (phenylene) polymer backbone is similar for all applications, with chemical functionalization of the backbone determining the application space. For example, sulfonation (functional group SO3H) is used for proton exchange applications (transportation fuel cells, acidic water electrolysis, and vanadium flow batteries), and functionalization with pendant quaternary guanidinium groups can be used for hydroxyl ion exchange applications (alkaline fuel cells for stationary power applications, alkaline water electrolysis). The poly (phenylene) backbone also provides chemical and thermal stability, an important requirement for high-reliability, low-cost energy-water systems.

Superior Crossover Performance

For proton exchange membranes used in acidic fuel cell systems, Sandia's technology is the only hydrocarbon membrane with performance meeting or exceeding the current state-of-the-art Nafion (Dupont) based membranes, with a projected cost structure below Nafion. In alkaline electrolysis and fuel cells, Nafion is not viable due to stability and cost. The Sandia alkaline polymer membrane opens up new markets through the use of non-precious metal catalysts, potentially lowering the cost substantially of energy-water systems. In vanadium redox flow batteries, the Sandia membrane is showing superior cross-over performance as compared to Nafion, thereby lowering operational and maintenance costs.

Technology Advancement

Facilitating interactions with industry and other research institutions would accelerate the commercialization of this technology in two areas:

1. The ability to gather additional performance and reliability data in integrated systems to further optimize the membrane chemistry for specific operating conditions and application environments.
2. The ability to develop a rigorous manufacturing cost and factory model.

Key technology improvement milestones include improving the chemical and mechanical durability in both acidic and alkaline conditions, and addressing materials and system integration issues.

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