Ionomr Innovations' Pemion® hydrocarbon-based proton exchange membrane and polymer exceed industry durability targets

Pemion® affirms itself as a viable and advantageous option to conventional per-fluorinated materials

Vancouver, B.C. | January 19, 2023 |Ionomr Innovations Inc.'s Pemion® has achieved performance and durability testing results that surpass internationally recognized standards from the US Department of Energy (US DOE) and Hydrogen Europe, confirming the company's proprietary hydrocarbon-based proton exchange membrane and polymer is ready for widespread heavy-duty fuel cell applications.

The Pemion® membrane was tested for and met established accelerated durability benchmarks for combined chemical and mechanical stress testing. Throughout **1,000 hours** of cyclical testing that exposed the membrane to intermittent dry and wet conditions under high-voltage chemical stress, Pemion® **exceeded the internationally recognized 20,000 cycle durability** targets set by the US DOE for polymer electrolyte membranes **by more than two-fold**.

As far as the company is aware, Pemion® is the first hydrocarbon-based membrane to ever pass these tests.

Pemion® is used in fuel cell applications including heavy-duty transport, automotive, and stationary power.

The materials have been designed to provide superior chemical, thermal, and mechanical stability, high conductivity, operational durability, and efficiency, all of which dramatically reduce the unit cost of the fuel cell.

- Pemion® materials' gains in performance and reductions in gas crossover result in a significant reduction in lifetime hydrogen fuel cell cost.
- Alongside improved fuel efficiency, the lifetime of the fuel cell is enhanced due to reduced degradation.
- Higher operating temperatures are possible for higher power stacks with improved cooling and heat rejection.
- Pemion® boasts one of the highest room temperature proton conductivities available under a variety of conditions, while maintaining its mechanical stability, allowing implementation in diverse systems from light to heavy-duty, and beyond.

"This testing confirms Pemion® as a differentiator for fuel cell manufacturers looking to overcome the challenges of a tight supply market for conventional polymer and membrane materials, without any trade-offs to lifetime or performance," said Ionomr CEO, Bill

Haberlin. "Fluorinated materials such as those currently used in fuel cells are good at what they do, but they require toxic and highly regulated chemicals to be produced. As regulations continue to tighten, fuel cell and stack manufacturers will need to find practical material replacements. Pemion® 's performance and durability record and environmentally benign hydrocarbon-base create a step-change alternative."

About Ionomr Innovations

Ionomr Innovations is revolutionizing electrochemistry with newly developed ion-exchange membranes and polymers for clean energy. Ionomr's Pemion® and Aemion® technologies provide cost, performance and sustainability advantages for fuel cells, hydrogen production and carbon capture, use and conversion. Leveraging technology developed at Simon Fraser University, Ionomr was founded in 2018, and employs 45 professionals in Vancouver, Canada and Rochester, New York. For more information about how Ionomr is helping to advance the clean energy economy, visit www.ionomr.com.

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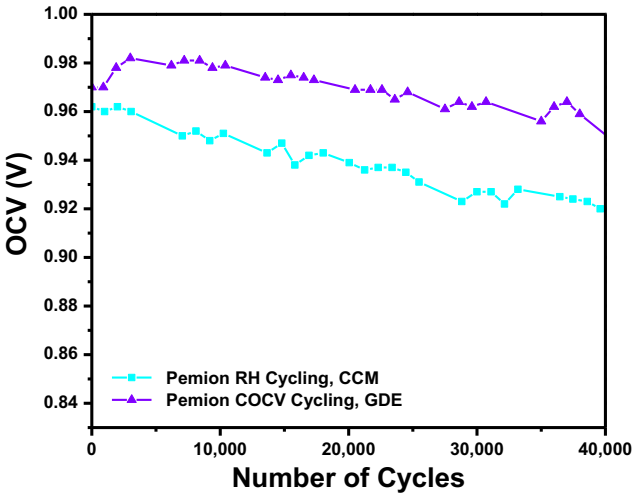
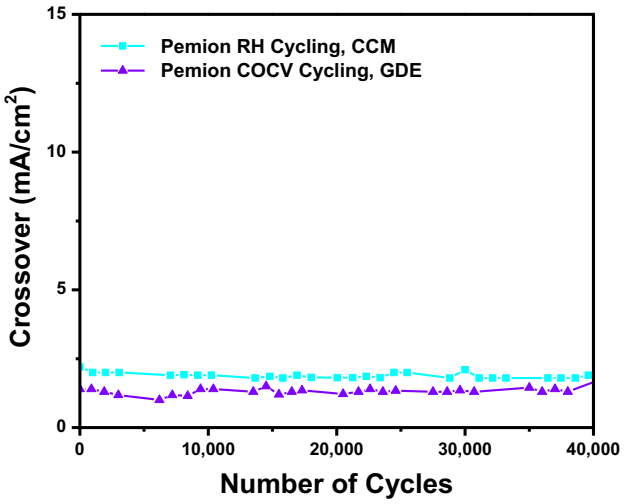
TECHNICAL BACKGROUNDER
PEMION® PERFORMANCE AND DURABILITY TESTING
JANUARY 2023

Summary

Performance testing on the Pemion® membrane and polymer included the US Department of Energy (DOE) "COCV" protocol – a combined chemical and mechanical stability accelerated stress test designed for fuel cell membranes – as well as the DOE RH cycling mechanical durability protocol. The tests, which were run for over 40,000 cycles with electrochemical assessments every 24 hours, demonstrated exceptional stability of the membrane in various membrane electrode assembly (MEA) configurations. Critically, MEAs containing Pemion® membranes exhibited minimal decreases in open circuit voltage (OCV) throughout the lifetime of the test, alongside exceptionally low and stable gas crossover.

These durability tests on Pemion® membranes show the material is fully capable of achieving and exceeding the DOE's 20,000 cycle target for fuel cell membranes – a target established to screen for viable materials to meet the ultimate goal of a heavy-duty fuel cell vehicle capable of operating for a million miles.





Background

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The tests were run for a minimum of 40,000 cycles following the DOE's Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.[1] Electrochemical diagnostics were performed every 24 h. As outlined in Table P.5 of the Fuel Cells section of this plan, the COCV protocol seeks to examine combined the effects of chemical and mechanical stressors on the membrane, within an operating fuel cell. This is accomplished by cycling the MEA from 0% RH (30 s) to 90°C dew point (45 s) at 90 °C cell temperature continually, until the membrane fails as a result of high gas crossover (leaking), or meets the 20,000-cycle target.

RH cycling mechanical stress tests were performed following the protocol outlined in Table P.5, except without the continuous OCV hold. Hence, the MEAs were cycled from 0% RH (30 s) to 90°C dew point (45 s) at 90 °C cell temperature continually. This is an important comparison to the COCV protocol because historically, hydrocarbon-based materials either fail due to chemical instabilities, or mechanical stressors as a result of swelling and deswelling during operation. Comparing the results of these two tests better highlights the capabilities of a given material.

MEAs were tested using both catalyst coated membrane (CCM) and gas diffusion electrode (GDE) configurations. The CCMs were fabricated internally using Ionomr's Pemion® membrane with common fuel cell catalysts (Pt/C) and ionomers (LSC PFSA). For MEAs tested using a GDE configuration, Pemion® membranes were used as-is and sandwiched between two commercially-available GDEs containing common fuel cell catalysts (Pt/C) and ionomers (LSC PFSA).

About Pemion®

PERFORMANCE ADVANTAGES OF PEMION™

Ionomr Innovations' hydrocarbon-based Pemion® membrane and polymer offers several advantages over incumbent perfluorinated materials to increase the efficiency, versatility, and lifetime of fuel cell engines in heavy-duty transport and automotive.

- Advantages include: i) lower gas crossover for increases to range and lifetime of both membrane and catalyst; ii) higher proton conductivity for additional gains to efficiency and power density; iii) significantly greater temperature stability to enable multiple system design benefits; and iv) substantially easier end-of-life precious metal recovery, reducing costs and eliminating the significant environmental concerns specific to acidic perfluorinated compounds.

- Reduced solubility of gases in the polymer leads to reduced crossover of both hydrogen and nitrogen, providing an immediate reduction in parasitic losses and considerably reduces the formation of highly reactive radicals to minimize chemical degradation for the longest possible system lifetimes.

[1] https://www.energy.gov/sites/prod/files/2016/06/f32/fcto_myrdd_fuel_cells.pdf

- Unlike PFSA materials, hydrocarbon Pemion® polymers are chemically stable up to 180 °C, enabling a development platform for other fuel cell components to address industry operating targets of 120 °C.

- Pemion® membranes are produced on reinforcement at thicknesses competitive to leading PFSA membranes in the industry, with record conductivity enabling the highest performance systems. As a result, Pemion® offers leading conductance and durability without compromise.

Production

Pemion® is produced roll-to-roll in a continuous, state-of-the-art membrane forming process with strict quality control. Each lot is carefully assessed for its mechanical and electrochemical characteristics to ensure robust batch-to-batch reproducibility. Pemion®, as a polymer, benefits from a unique synthetic protocol that allows for production of a highly consistent polymer with the same degree of functionality every time, eliminating concerns about batch-to-batch reproducibility often seen in other materials, perfluorinated or not.

Environmental and Social Benefits

Membrane materials and polymers commonly in use today are comprised of perfluorinated compounds (perfluorosulfonic acids, PFSAs, a sub-class of PFAS). This class of materials, including the precursors used to make them, are known to be serious, bio-accumulative environmental toxins with impact at concentrations as low as one part per trillion. Disposed of in solid form, they leach into water sources and accumulate biologically in living organisms where they cause numerous negative health effects.

Ionomr's vision is to develop advanced ion-exchange membranes using modern green chemistry techniques to accelerate the green hydrogen economy. Ionomr synthesizes membranes and polymers from a hydrocarbon base that demonstrates no bio-accumulative tendencies and are non-toxic to the environment. The company's green technologies are fully recyclable and recoverable and are ideal replacements for present membrane and polymer products containing PFAS.

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