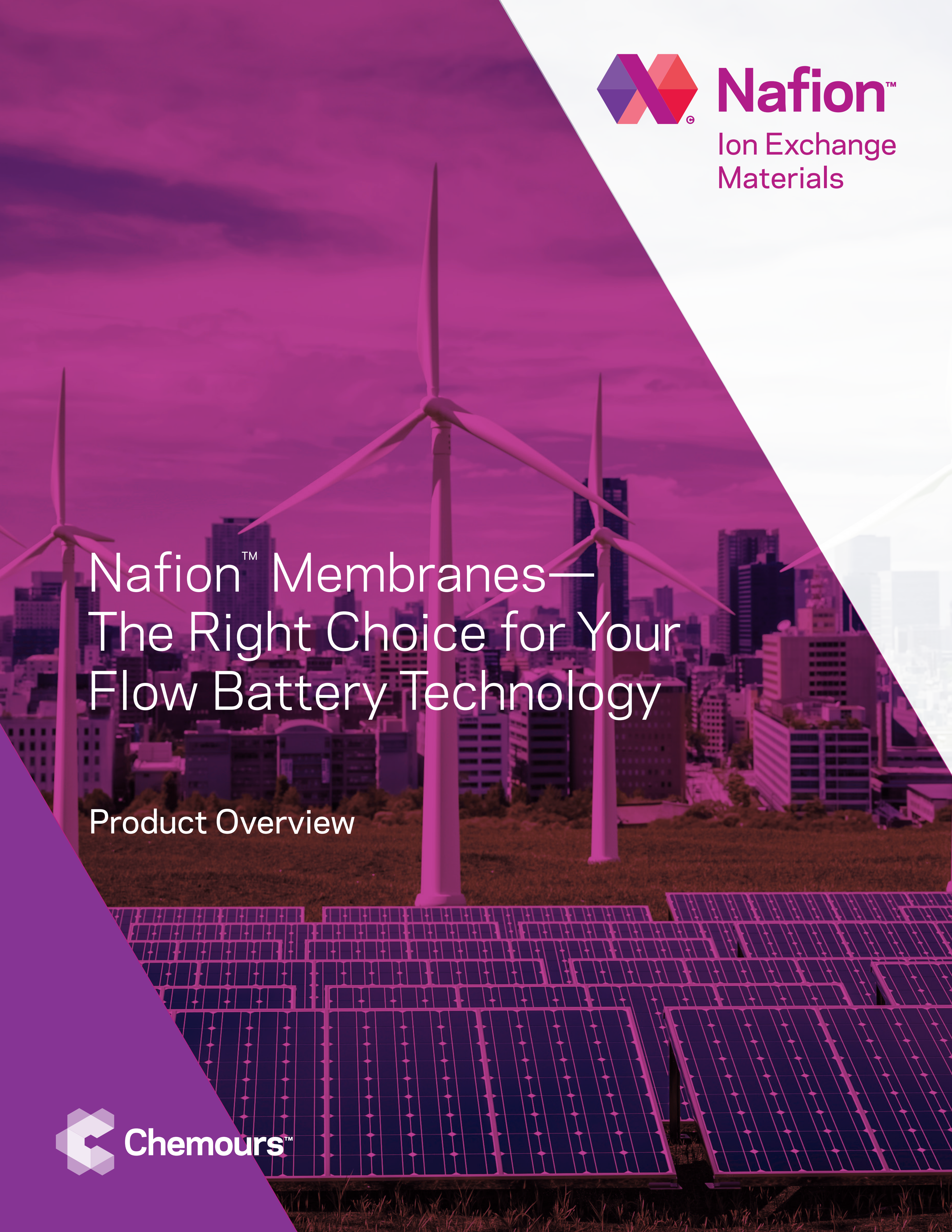


Nafion™

Ion Exchange Materials

Nafion™ Membranes— The Right Choice for Your Flow Battery Technology

Product Overview

Chemours™

Solutions for the Energy Industry Powered by Chemours Science

Nafion™ perfluorosulfonic acid (PFSA) polymer was invented by Chemours, formerly DuPont, in the 1960s, and commercial scale production started in 1979 at Fayetteville, North Carolina. Nafion™ resins, membranes, and solutions are based on copolymers of tetrafluoroethylene (TFE) and functionalized perfluorocarbon vinyl ethers. Nafion™ has been widely used as a separator and solid electrolyte in a variety of electrochemical cells that require the membrane to selectively transport cations across the cell junction.

Over 50 years, Nafion™ served a wide range of electrochemical applications in space, military, energy, and other various industries—the primary application being the production of chlorine and caustic by electrolysis. For more than 30 years, Nafion™ has been the preferred membrane in the chloroalkali industry due to the significant operating and cost advantages it provides over older mercury and diaphragm technologies, as well as other membranes.

For the emerging global flow battery market, Nafion™ is also becoming the preferred membrane.

Energy Storage—Nafion™ Innovations for Today's Growing Energy Demand

The rising global population, set to reach 10 billion by 2050, and GDP growth, are driving an increasing demand for electricity. At the same time, the need for a lower carbon future requires both improved energy efficiency and the development and adoption of new technologies that meet this demand.

Energy storage becomes an important player, as a way to bring cost savings to utilities and consumers, support smart grid structure, and improve the implementation of renewable energy. The energy storage industry continues to evolve and adapt to the requirements of the growing energy demand of the world.

Flow batteries are a type of technology with significant potential to meet the requirements in a wide range of energy storage applications from kilowatt-hour to megawatt-hour capacity. The applications for flow batteries include load leveling, voltage sag compensation, emergency power supply, stabilization of output fluctuation, and frequency regulation. Flow batteries offer economical, safe, and low environmental footprint solutions, as well as low vulnerability systems to store electrical energy.

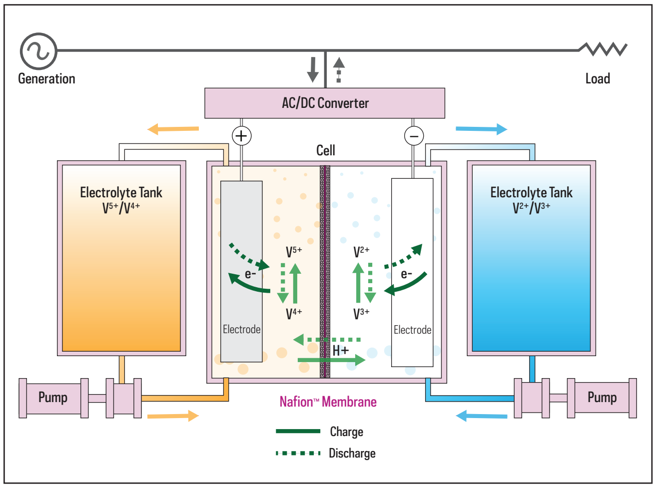
Flow batteries have several advantages over other battery types. In contrast to conventional batteries, the electroactive materials are stored externally. This feature makes power and energy ratings independent in flow batteries, allowing easy scalability. Flow batteries are increasingly being regarded as more cost-effective than conventional batteries for large energy storage applications. In addition, flow batteries offer easy maintenance, better thermal management, and longer cycle life.

A flow battery generates power by supplying solutions from external tanks to an electrochemical cell. The solutions comprise electroactive materials and non-reactive supporting electrolyte. The anode and cathode electrodes are separated by a membrane. The electroactive species undergo a reversible reaction on the electrodes, and the non-reactive ions are transported through the membrane to provide charge balance during charge-discharge cycles. The solution is stored in external tanks and pumped to the electrochemical cell on demand.

The ion exchange membrane (IXM) is a key enabler for flow battery technology. The IXM prevents mixing of positive and negative electrolytes and allows transport of non-reactive ionic species during operation. Ionic conductivity is the most important factor of IXM. In addition, membranes are expected to have an extended lifetime and excellent chemical and physical resistance.

Flow Battery Energy Storage Unit

Figure 1. Flow Battery



Nafion™ Membranes—The Right Choice for Your Flow Battery Technology

Low Ionic Resistance

Energy conversion systems require low resistance to maximize efficiency. The membrane gives the largest contribution to internal resistance. Nafion™ membranes provide excellent ionic conductivity and are available in various thicknesses to offer a good balance between membrane resistance and other parameters, such as strength and selectivity.

Extended Lifetime

Large scale energy storage applications require a long lifetime (over 10 years). The cell components must survive during the service lifetime of the battery. Typically, depending on the specific chemistry of a flow battery, extreme pHs are necessary to have enough charge carriers and keep electroactive species solvated. A strong pH environment coupled with the strong oxidation potential of electroactive species result in harsh conditions for battery components.

Nafion™ membranes are a copolymer of TFE and perfluorinated monomers containing sulfonic acid groups. Nafion™ membranes have an extraordinary chemical and thermal stability, and their durability has been proven in various electrochemical applications, e.g., fuel cells, chloralkali electrolyzers, and water electrolysis.

Nafion™ membranes have good mechanical strength. Reinforced Nafion™ membranes are also available for the applications where a mechanical stress is applied on membranes during cell assembly and operation.

Product Lines

There are various types of flow batteries, with each one having its own characteristics and performance requirements. The Nafion™ product portfolio includes a variety of membranes to meet the requirements of different flow battery types. Thicknesses vary from 25–210 microns.

Nafion™ membranes are available with reinforcement of polytetrafluoroethylene (PTFE). PTFE reinforcement significantly improves the mechanical strength of the membrane without sacrificing its chemical durability.

Chemours is the world's leading supplier of ion exchange materials. Our high-volume manufacturing capacity, large portfolio of products, and excellent technical support can help customers meet their performance requirements and support their commercialization processes.

The need for clean, sustainable, and affordable energy storage has never been greater. Chemours is accelerating advancements in flow battery technology with innovative materials and engineering solutions for future energy storage available today. We are partnering with business leaders to develop the best solutions for flow battery energy storage systems.

Table 1. Properties of Nafion™ Membranes

	Thickness (μm)	Linear Expansion[1] (%)	Strength[2] (MPa)		Areal Resistance[3] (mΩ cm²)	Flux Constant VO2+ ($x\ 10^{-4}$ cm min^{-1})
			MD	TD		
NR211	25	10	23	28	45	6.3
NR212	50	10	25	25	80	2.7
NR220	210	<3	18	6	112	2.0
N115	125	10	31	27	160	1.3
N117	180	17	36	33	220	0.8

[1]% increase from 50% RH, 23 °C (73 °F) to water soaked, 23 °C (73 °F)
[2]Membranes are conditioned to 23 °C (73 °F), 50% RH, ASTM 882; MD = machine direction, TD = transverse direction
[3]Ionic resistance measured in 2.5 M H_2SO_4

The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits nor used alone as the basis of design. This information is based on technical data that Chemours believes to be reliable. It is intended for use by persons having technical skill and at their own discretion and risk. This information is given with the understanding that those using it will satisfy themselves that their particular conditions of use present no health or safety hazards. Because conditions of product use are outside our control, Chemours makes no warranties, express or implied, and assumes no obligation or liability in connection with any use of this information or for results obtained in reliance thereon. The disclosure of the information is not a license to operate under or a recommendation to infringe any patent of Chemours or others.

Medical Statement: Please contact your Chemours representative to discuss limitations regarding medical applications.

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