Nafion™
Ion Exchange Materials

Nafion™ Materials Circularity Case Study

Chemours' commitment to circularity is evident in our efforts to develop sustainable solutions, promote reduction, reuse and recycling, plus collaborate with customers and stakeholders. By prioritizing circularity, Chemours is working towards a more sustainable future in which resources are managed efficiently, waste is minimized, and environmental impacts are reduced.

Introduction

Chemours is actively working to integrate circular principles into its business models and product designs, with a holistic view of the lifecycle. We emphasize the importance of reducing the environmental footprints of our operations and those of our customers by implementing innovative solutions that promote reduction, recycling, reuse, and repurposing of materials.

Chemours also is engaging in collaborations and partnerships to drive circularity across industries. By working together with customers, suppliers, and other stakeholders, we aim to develop comprehensive solutions that promote resource efficiency and waste reduction.

Circularity in Ion Exchange

The performance and durability of Nafion™ ion exchange membranes make them the products of choice for chlor-alkali electrolysis. They offer leading-edge solutions for energy storage, fuel cells, water electrolysis, ultra-high purity chemical production, and other specialty applications.

Applications in which ion exchange membranes are used include:

Energy Production

Fuel cells to convert hydrogen to electricity

Hydrogen Production

Water electrolyzers to convert water to hydrogen and oxygen

Water Purification

Desalination by electrodialysis

Advanced Electronics Manufacturing

To make and maintain ultrahigh purity specialty chemicals needed for modern day fabrication of integrated circuits

Energy Storage

Storing energy in flow batteries to stabilize the energy grid and increase renewable energy utilization

Chemical Production

Manufacturing chemicals using electricity to increase energy efficiency and decrease by-products. For example, the chlor-alkali process that makes chlorine

As the world at large moves towards electrification and decarbonization, the growth rate of many of the applications mentioned in this paper is outpacing membrane supply capacity.

With the aim of reducing reliance on virgin materials and contributing to the circular economy, the Chemours Nafion™ Technology Team has undertaken a feasibility study. The purpose was to determine whether it was possible to isolate, recover, purify, and recycle Nafion™ polymers from used chlor-alkali (CA) membranes.

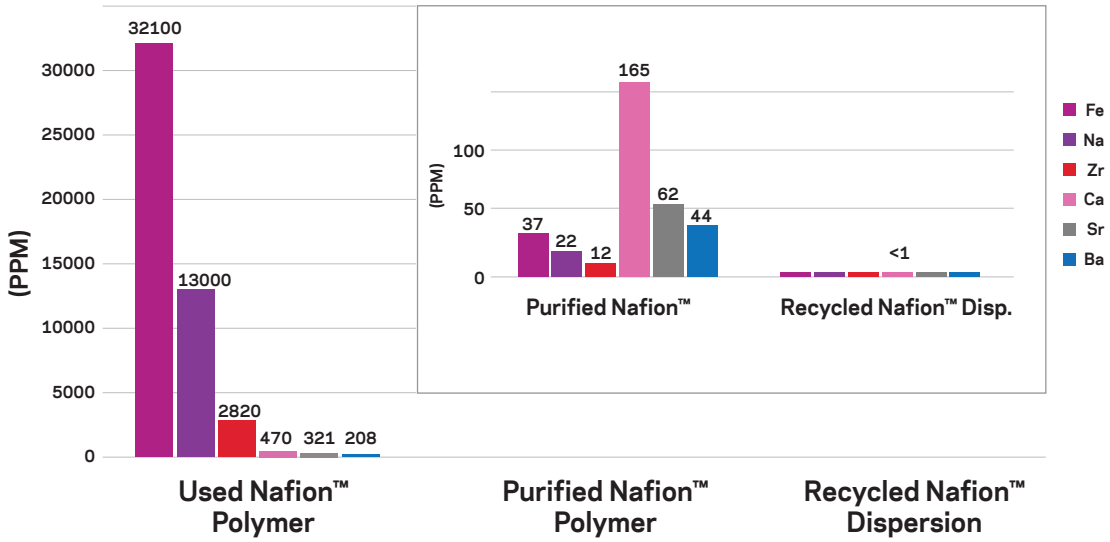
Testing the Recycling Process

Nafion™ ion exchange membranes have a unique combination of properties. In chlor-alkali applications, they are designed to excel across a wide range of operating conditions, minimizing process interruptions and downtime, offering consistent production and low energy consumption. Over time, performance in any membrane can decline due to impurity accumulation.

The objective of the Chemours Nafion™ recycling study was to determine the technical feasibility of extracting impurities and reprocessing the membrane to obtain a recycled film, the properties of which could then be evaluated.

The study involved the collection of post-industrial chlor-alkali (CA) membranes N2030 and N2050 from customers. The polymer from the used CA membranes exhibited high levels of impurities such as iron (over 30,000 ppm) and sodium (13,000 ppm). Other contaminants at lower levels were also present. After undergoing a multi-step process, the contaminants in the resulting recycled Nafion™ dispersion were less than 1 ppm. See Figure 1.

Figure 1. Impurity levels in recycling process



The investigation demonstrated that the removal of contaminants from other membrane components can be achieved, with less than 1 ppm of each contaminant in the 100% recycled CA post-industrial Nafion™ dispersion (see Table 1). The high purity levels demonstrated by the study are particularly impressive when compared with the purity and performance specifications for standard Nafion™ dispersion. Moreover, Table 2 highlights no appreciable difference in acid capacity between films made from unused polymer and films made from reclaimed CA polymer.

Table 1. Comparison of Impurities to Specification

	Standard Nafion™ Dispersion Specifications	100% Recycled Chlor-alkali Nafion™ Dispersion
Iron (ppm)	< 50	< 1
Chromium (ppm)	< 50	< 1
Nickel (ppm)	< 50	< 1
Potassium (ppm)	< 100	< 1

Table 2. Acid Capacity of Films Made From Recycled Polymer Compared to Virgin Materials

Product	Total Acid Capacity (meq/g)
Standard Nafion™ Cast Film	0.95 - 1.10
100% Recycled CA Post-Industrial Nafion™ Cast Film	1.03 ± 0.01

The Chemours Reasearch and Development Team continues to explore techniques to enable the recycling of Nafion™ ionomers from used membranes and various applications.

The Journey to Circularity

The potential, as identified in this study, to isolate, recover, purify, and recycle Nafion™ membranes is an exciting step in Chemours' development of innovative, high-performance products that address the sustainability needs of our customers. Polymers, in general, take a very long time to break down in the environment.

Nafion™ polymers present a unique opportunity to recover the polymer itself due to its high chemical durability.

The Chemours Nafion™ Technology Team has the knowledge and expertise to help enable these industries on their transformative journey towards a safer, cleaner world. This journey encompasses closing the circularity loop by utilizing fewer resources, prolonging the use of existing products and materials, generating less waste and actively promoting polymer reuse and recycling.

1, https://www.theworldcounts.com/challenges/planet-earth/state-of-the-planet/overuse-of-resources-on-earth
2, https://circulareconomy.europa.eu/platform/sites/default/files/1._report_cgr_global_2022.pdf

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