FLUOROPOLYMERS:

Powering EVs toward UN SDGs and a more sustainable value chain

Introduction

According to the World Health Organization (WHO), climate change is the biggest health threat facing humanity, with vehicle greenhouse gas emissions (GHG) playing a significant role in the current environmental crisis.[1] To move us toward a more sustainable future, the United Nations (UN) adopted the Sustainable Development Agenda in 2015, which set forth a list of Sustainable Development Goals (SDGs) as the blueprint for addressing the global challenges we face, including defusing the threats posed by climate change.[2] Considering road vehicles account for 77% of all transport emissions, transitioning to electric vehicles (EVs) is critical in our path to achieving UN SDGs. But chemical innovation and advanced materials are required to improve the manufacture of next-gen EV components and allow production to reach scale. This white paper will discuss the critical role advanced materials like fluoropolymers play in maximizing the benefits of our transition to EVs and in advancing UN SDGs. By selecting a partner focused on creating more sustainable solutions through chemistry, forward-thinking automotive manufacturers will be able to make a significant contribution to climate change mitigation and help us all move toward a better world.

[1] World Health Organization. Climate change and health
[2] Historic New Sustainable Development Agenda Unanimously Adopted by 193 UN Members

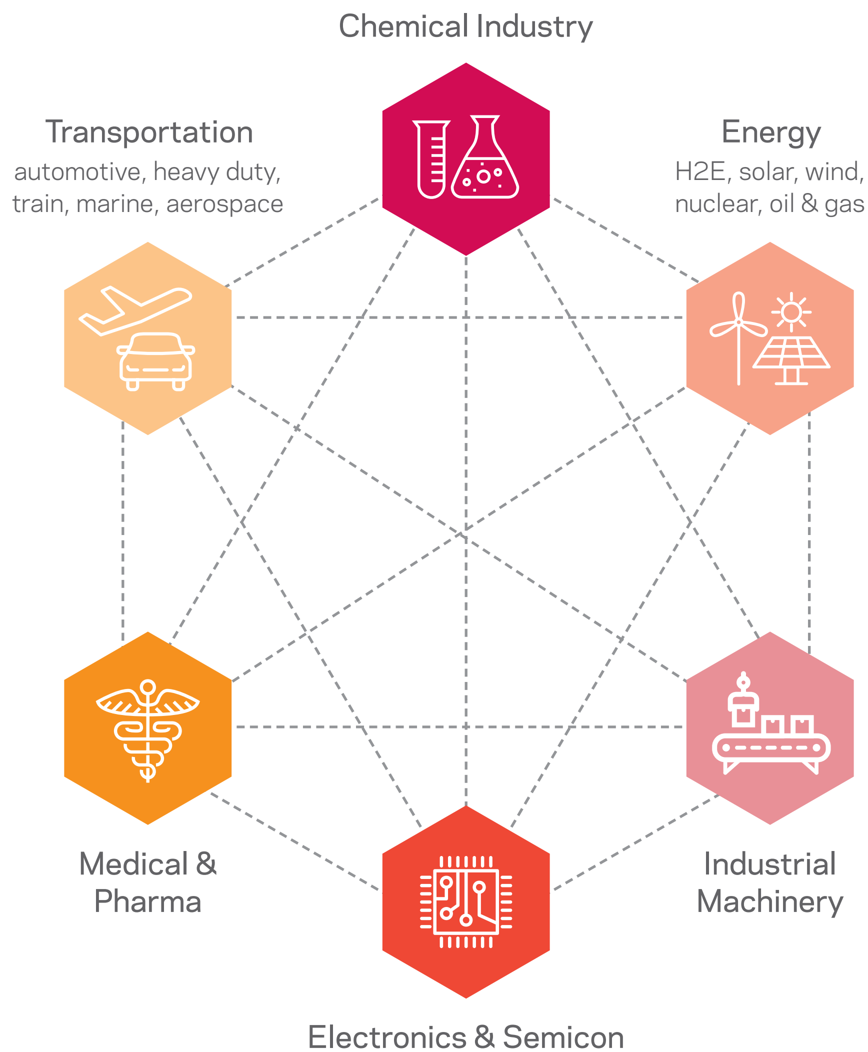
Why fluoropolymers? Our future depends on chemical innovation

Fluoropolymers are advanced materials that possess a unique combination of properties, including chemical inertness, thermal stability, low-permeability, resistance to extreme temperature, low friction, and superior dielectric properties. Because of this, fluoropolymers have been used for decades to improve engine efficiency, safety, and emissions control of internal combustion engine (ICE) automobiles.

Looking forward, they play an integral role in the design of the batteries, e-motors, and complex components that enable more sustainable electric vehicles and are used in multiple applications throughout EVs, including battery electrode binders, seals, gaskets, O-rings, sensor cables, wire insulation, and more.

In addition to the many benefits fluoropolymers bring to EVs, their superior qualities, as mentioned above, have made them fundamental to the advancement of a variety of interconnected sectors such as advanced electronics and clean energy applications. As of today, there are no known alternatives that possess the unique combination of properties fluoropolymers offer while delivering such a high level of performance.

All sectors are connected, one sector cannot exist without the others



Sustainable Development Goals: A blueprint toward a more sustainable future

In 2019, 99% of the world's population was living in places where the WHO air quality guidelines levels, based on particulate matter (PM), ground level ozone, CO_2, SO_2, and NO_2, were not met, and internal combustion engine (ICE) transportation is a major contributor to these air pollutants.[3]

Here, we've included some of the SDG targets outlined by the UN that set the bar for protecting the planet and the health of everyone on it. Chemours contributes to the UN SDGs through our commitment to creating high-performance materials that improve energy efficiency and lower emissions. The fluoropolymers we produce are integral to progressing these goals for many reasons, one being their intrinsic properties that can improve the performance and economics of EVs.

Traditional lithium-ion batteries (LiBs) contain a cathode (positive electrode) and an anode (negative electrode). Manufacturing the films involves a wet, slurry-based electrode fabrication process. The cathode process conventionally uses N-methyl-2-pyrrolidone (NMP). However, NMP is classified as a reproductive toxicant and a Substance of Very High Concern by the European Chemical Agency.

UN SDG Target 8.8:

Protect labor rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.

By contrast, cathodes can be made using advanced fluoropolymer binders with Teflon™ PTFE in a dry electrode coating process that avoids using NMP altogether, thereby contributing to SDG Target goal 8.8 by decreasing worker exposure and risk.[4-5]

NMP requires expensive solvent recycling equipment, making the slurry-based fabrication process costly, more energy-intensive, and less sustainable.

Unlike the wet slurry-based methods, dry electrode coating uses advanced fluoropolymer binders with Teflon™ PTFE. Compared to the wet slurry-based method, this dry electrode coating process has the potential for producing thicker electrodes, which improves battery energy density and performance.[6]

UN SDG Target 7.3:

By 2030, double the global rate of improvement in energy efficiency.

UN SDG Target 9.4:

By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

Dry electrode coating eliminates the drying and solvent recovery steps, reducing energy consumption by ~47% and the LiB manufacturing cost by 20%.[7] Lower energy consumption and reduced CO_2 emissions contribute to SDG Targets 7.3 and 9.4.

[3] United Nations World Health Organization, Ambient (outdoor) air pollution
[4] European Chemicals Agency, Member State Committee Support Document for Identification of 1-methyl-2-pyrrolidone as a Substance of Very High Concern Because of Its CMR Properties

UN SDG 12.2:

By 2030, achieve the sustainable management and efficient use of natural resources.

UN SDG Target 12.4:

By 2020, achieve the environmental sound management of chemicals and all wastes throughout their life cycle in accordance with the agreed international frameworks, and significantly reduce their release to air, water, and soil in order to minimize their adverse impacts on human health and the environment.

UN SDG 12.5:

By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse.

By eliminating the need for drying and solvent recovery from the process, land use and the overall manufacturing footprint are reduced by up to 70%,[8] thus moving us closer to achieving UN SDG Target 12.2.[9] More importantly, by eliminating the drying step, NMP emissions to the environment from solvent handling and evaporation steps are avoided. As a critical element of the LiB dry electrode coating process, advanced fluoropolymer binders with Teflon™ PTFE eliminate the need for NMP, as mentioned above, while reducing emissions by removing the drying process.

As discussed earlier, fluoropolymers' low-permeability and chemical inertness make them an ideal material for use in EV seals, gaskets, O-rings, tubes, and hoses. They can withstand aggressive e-fluids, chemicals, and extreme temperatures and prevent fluid leakage into the environment. All of these factors make fluoropolymers a vital contributor to advancing UN SDG Target 12.4.

When used in EV applications, fluoropolymers enable vehicle components to withstand chemical attack and maintain durability and performance for extended periods of time. By reducing the need for repairs and keeping vehicles and their components in circulation longer, fluoropolymers prevent vehicle parts from becoming waste, thereby directly contributing to UN SDG Targets 12.2 and 12.5.

[5] United States Environmental Protection Agency, Fact Sheet: N-Methylpyrrolidone (NMP)
[6] A 5 V-class cobalt-free battery cathode with high loading enabled by dry coating, Energy and Environmental Science, 16 February 2023
[7] Y. Liu , R. Zhang , J. Wang and Y. Wang , iScience, 2021, 24, 102332 https://doi.org/10.1016/j.isci.2021.102332
[8] Dry Coating Process for Battery Electrodes: Environmentally friendly, cost efficient, space and energy saving.
[9] The Role of Responsible Manufacturing in Hydrogen Production and the Clean Energy Transition

Fluoropolymer Applications in Electric Vehicles

Teflon™ Coatings
Teflon™ Fluoropolymers
Viton™ Fluoroelastomers
Tefzel™ Resins

Lithium-Ion Battery

Battery Electrode Binders, Battery Cell Gaskets, Battery Active Material Equipment Coatings, Sensor Cables

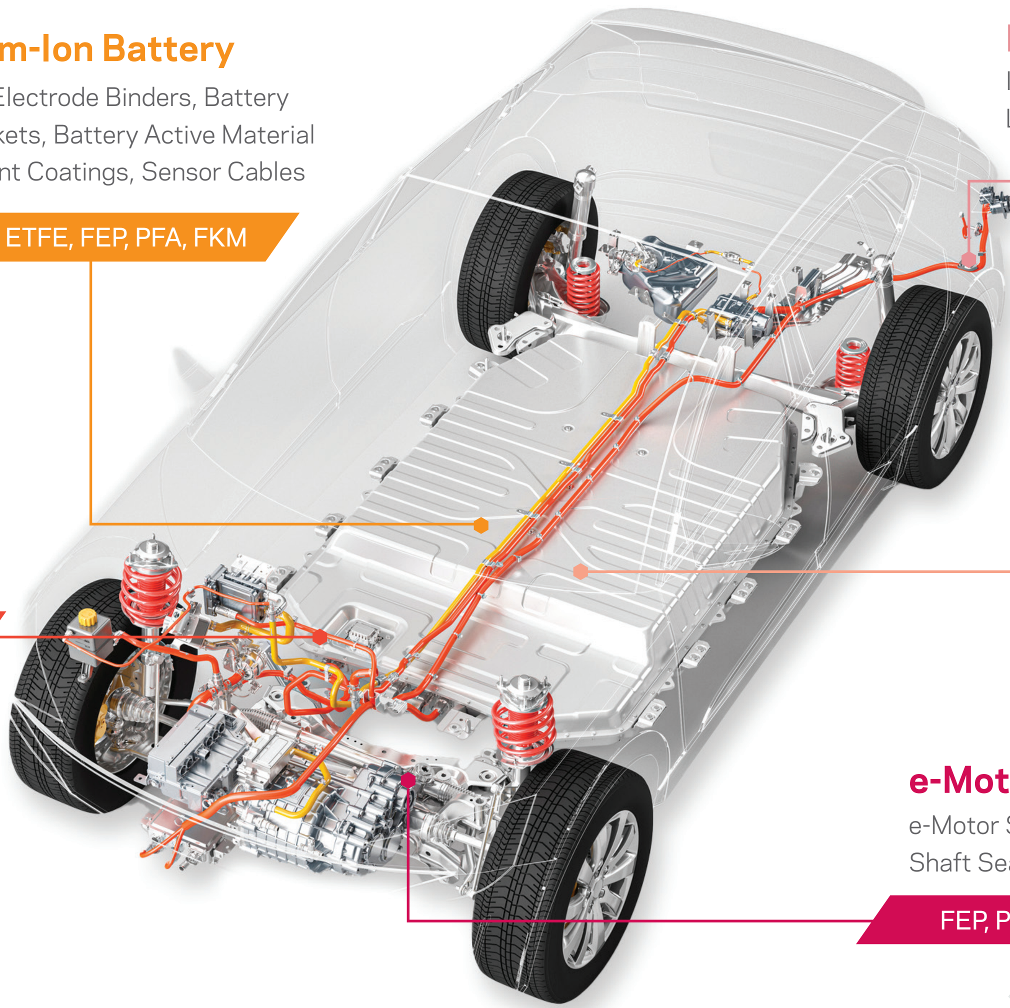
PTFE, ETFE, FEP, PFA, FKM

Noise, Vibration, & Harshness

Interior or Exterior Materials, Charging Port Latches and Cable Connectors

PFPE

Krytox™ Lubricants



Vehicle Thermal Management

Refrigerants for Air Conditioning and Heat Pumps, Immersion cooling fluids for Batteries, Charging Stations, Power Electronics

HFO

Opteon™

Electrical Systems

High Voltage Power Cables, Busbar Insulation, Transformer Wire Insulation

ETFE, FEP, PFA, FKM

Teflon™ Coatings
Teflon™ Fluoropolymers
Viton™ Fluoroelastomers
Tefzel™ Resins

e-Motor & e-Axle

e-Motor Seals & O-rings, e-Motor Shaft Seals, Sensor Cables

FEP, PTFE, PFA, FKM, ETFE

Teflon™ Fluoropolymers
Viton™ Fluoroelastomers
Tefzel™ Resins

An ongoing commitment to global sustainability through the advancement of EVs

Chemours recognizes the importance of EVs in our journey to transitioning toward a healthier planet. And there's no doubt the power of chemistry makes this possible. While our portfolio of products is specifically designed to deliver sustainable solutions for enhanced performance across a wide variety of sectors, products, and applications, the following products help drive the success of the EV evolution:

Teflon™ Fluoropolymers — Tefzel™ Resins

- Advanced fluoropolymer binders based on **Teflon™ PTFE** are used in the development of solvent-free battery dry electrode coating that will enable more cost-effective and energy-efficient battery manufacturing
- **Teflon™ PTFE, PFA, FEP, and Tefzel™** optimize efficiency of high voltage circuits and systems with best-in-class electrical properties and high temperature resistance

Krytox™ Lubricants

- **Krytox™** performance lubricants keep noisy, rattling, and vibrating vehicle components quiet for every ride

Viton™ Fluoroelastomers

- **Viton™** fluoroelastomers support e-motors and lithium-ion batteries in electric vehicles, providing greater e-fluid, chemical, and thermal resistance for seals, gaskets, O-rings and cables

Nafion™ Ion Exchange Materials

- Our **Nafion™** proton exchange membranes (PEM) are central to FCEV (fuel cell electric vehicles) and enable longer driving ranges and increased fuel efficiency

It's more than electric. It's chemistry.

Electric powers the future, but chemistry is the catalyst. Chemours' Advanced Performance Materials make next-gen components possible so that state-of-the-art EVs charge faster, are more sustainable, drive further, and run for years to come.

The future is ours

Achieving sustainability is only possible if we all make the commitment together. It needs to be carried through in our words and actions, products and innovations, and goals and vision for the future. A goal set forth in our Chemours 2030 Corporate Responsibility Commitment is that 50% or more of our revenue will be from offerings that make a specific contribution to the United Nations Sustainable Development Goals (UN SDGs). We are on track to meet this commitment, with 48.2% of our revenue contributing to the UN SDGs as of 2022.

To learn more about Teflon™ fluoropolymer solutions for electric vehicles (EVs), please visit:

chemours.com/industries-applications/electric-vehicles

To find out more about the Chemours™ commitment to sustainability and how our advanced performance materials can help you meet and exceed your EV design needs, contact us today.

https://www.chemours.com/en/contact

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