Chemours™ Fluoroproducts

ECChreme™ ECA Fluoropolymer Resin
WE ARE CHEMOURS

The Chemistry for what’s next starts now.

We are a world leader in titanium technologies, fluoroproducts, and chemical solutions. We are a new company with over 200 years of history, created from the DuPont performance chemicals businesses.

Chemistry that shapes markets.

We are catalysts for change. Our chemistry makes processes more efficient, products more valuable, and businesses more competitive. We are also catalysts for better. We help meet global demand for higher living standards in ways that are safer for everyone.

Our purpose

We help create a colorful, capable, and cleaner world through the power of chemistry.

Our values

**Customer-Centered.**
Drive customer growth, and ours, by understanding their needs and building long-lasting relationships

**Refreshing Simplicity.**
Cut complexity, invest in what matters, and get to results faster

**Collective Entrepreneurship.**
Act like you own the business, while embracing the power of inclusion and teamwork

**Safety Obsession.**
Live our steadfast belief that a safe workplace is a profitable workplace

**Unshakeable Integrity.**
Do what’s right for customers, colleagues, and communities, always
The Chemours™ Fluoroproducts organization is committed to being the established and recognized leader in providing quality products and services to our customers.

In pursuit of this goal, we will continuously improve our products, processes, and operating systems to enable us to meet or exceed the customer needs that are consistent with our business strategy.

A primary concern of our company and organization is the quality of our products and services. In order to be successful, we offer products or services that:

- Meet a well-defined need, use, or purpose
- Satisfy customers’ expectations
- Comply with applicable standards and specifications
- Comply with statutory (and other) requirements of society
- Are made available at competitive prices
- Are provided at a cost that will yield a profit


Safety

Industrial experience has proven that adequate ventilation, in properly maintained processing and handling areas, will eliminate known hazards to personnel during processing and handling of Teflon™, Tefzel™, ECCtreme™, Viton™, and Zonyl™ resins and dispersions.

Resin containers should be opened and used in well-ventilated areas. Equipment used to process at melt temperatures should be provided with local exhaust ventilation to completely remove all fumes and vapors from the processing area. In addition, care should be exercised to avoid the contamination of cigarettes and other forms of smoking tobacco when using fluoropolymer resins.

Extruders and molding equipment used to process fluoropolymers should be constructed of high nickel alloy, corrosion-resistant materials and capable of operating at temperatures up to 400 °C (750 °F).

Before using, personnel should read the Safety Data Sheet (SDS) and detailed information in “Guide for the Safe Handling of Fluoropolymer Resins” published by PlasticsEurope (Association of Plastics Manufacturers, Brussels, Belgium).
The 300 °C option.

Developed with chemistry that goes beyond traditional design boundaries for very hot, harsh environments, ECCtreme™ ECA expands currently available options for wire and cable, molded parts, and extruded tubing and lining.

ECCtreme™ ECA resins surpass the long-standing upper-use limit of 260 °C (500 °F) in traditional perfluoropolymers, extending the limit by 40 °C (104 °F)*. This unique feature is achieved through a phenomenon known as epitaxial co-crystallization (ECC).

Customer-driven chemistry.

Starting back in 1938 with the discovery of PTFE, Chemours has pioneered innovations in fluoropolymer technologies; driven by the increasingly demanding needs of the industries they support, the development of ECCtreme™ ECA fluoropolymer resin in 2011 was no different.

ECCtreme™ ECA was created as an answer to oil field service providers, who needed a wire and cable solution to support oil and gas drilling in increasingly harsh environments, including deeper wells and high-temperature extraction methods. While the chemical resistance, electrical properties, and melt processability of traditional perfluoropolymers were a fit, the upper-temperature rating was now a limitation. Downtime and equipment damage caused by cable failure were ongoing and costly concerns.

*Measured according to UL 746B testing

"This is the first fluoropolymer of its kind. It was developed to withstand the harsh, high-heat environments found in energy production applications."

Dr. Jacob Lahijani, a Senior Research Associate at Chemours, conducted extensive experimentation in fluoropolymer crystallization. He then collaborated with strategic industry partners to demonstrate performance in several high-temperature applications for the energy industry, including insulation for power and data cables, valve seats, packer seals, and blowout preventer and flow valves.
<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution: Chemours™ Fluoropolymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion, Release</td>
<td>Extremely low surface energy in the solid state; thus, providing an excellent anti-stick, non-wetting contact surface. Conversely, when these resins are in a molten state, they become low surface-tension liquids—ideal for high-performance, hot-melt adhesives.</td>
</tr>
<tr>
<td>Atmospheric Aging</td>
<td>Extremely resistant to oxidation, surface fouling, discoloration, UV light, and embrittlement.</td>
</tr>
<tr>
<td>Biodegradation</td>
<td>Inert to enzymatic and microbiological attack because the pure plastic does not provide nourishment or porosity for these growths.</td>
</tr>
<tr>
<td>Contamination</td>
<td>Except for specialized grades, Chemours™ fluoropolymers are chemically inert and pure. They generally contain no additives—plasticizers, stabilizers, lubricants, or antioxidants—which could contaminate process fluids.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Resistance to even the most aggressive organic and inorganic chemicals and solvents over a broad temperature range.</td>
</tr>
<tr>
<td>Dielectric Instability</td>
<td>High dielectric strength, low dielectric constant, low loss factors, and extremely high specific resistance. Chemours™ fluoropolymers surpass most materials in their level and stability of dielectric properties over a broad range of environmental conditions.</td>
</tr>
<tr>
<td>Flammability</td>
<td>Remarkable resistance to high temperature and flames because of very high melting points and auto-ignition temperatures, as well as exceptional thermal degradation thresholds. Flame propagation characteristics, such as rate of heat release and smoke generation, are very low.</td>
</tr>
<tr>
<td>Friction and Wear</td>
<td>One of the lowest coefficients of friction of any solid material. Abrasion resistance is adaptable to demanding environments by using inorganic fillers, such as glass fiber, carbon fiber, and graphite.</td>
</tr>
<tr>
<td>Heat</td>
<td>Property retention after exposure to temperatures beyond the limit of almost all other thermoplastics and elastomers. Depending on the end-use requirements, these resins are often rated for continuous service at temperatures as high as 300 °C (572 °F).</td>
</tr>
<tr>
<td>Humidity</td>
<td>Extremely hydrophobic and completely resistant to hydrolysis. Good barriers to water permeation; typical properties and dimensional stability remain unchanged, even after year-long immersion in water.</td>
</tr>
<tr>
<td>Light Instability</td>
<td>One of the lowest refractive indexes. Visual appearance does not change after exposure to light ranging from ultraviolet to infrared.</td>
</tr>
<tr>
<td>Low Temperature</td>
<td>Excellent property retention, even at cryogenic temperatures. In addition, resistance at these temperatures exceeds that of most other plastics.</td>
</tr>
<tr>
<td>Service Life</td>
<td>Outstanding retention of properties after aging, even at high temperatures and in the presence of solvents, oils, oxidizing agents, ultraviolet light, and other environmental agents. Because they do not contain stabilizing additives, which could leach out or degrade over time, Chemours™ fluoropolymers offer an important safety advantage when designing products for service life.</td>
</tr>
</tbody>
</table>
WHAT IS ECA?

With brands like Teflon™, Tefzel™, and ECCtreme™, Chemours has been at the forefront of fluoropolymers innovation for over 75 years.

This new class of high-temperature fluoropolymer material is known as an epitaxial co-crystallized alloy or ECA.

What Is An Epitaxial Co-Crystallized Alloy?

Recognized by UL as a new class of fluoropolymer resin, ECCtreme™ ECA exhibits a unique coupling and crystallization effect when exposed to temperatures above 280 °C (536 °F). This coupling effect is known as epitaxial co-crystallization.

This unique phenomenon is characterized by an increase in crystallinity via two distinct processes: spherulite growth within the crystal structure and end-to-end coupling of the polymer chains.

No other product in the market provides the combination of properties that ECCtreme™ ECA brings to the industry.
ECCtreme™ ECA is extremely stable at high temperatures. While traditional fluoropolymer materials can be used continuously up to 260 °C (500 °F), ECCtreme™ ECA is recognized by UL as having a 300 °C (572 °F) upper continuous-use temperature.

At cryogenic temperatures, fluoropolymer products retain toughness and strength.

Chemours™ fluoropolymers are extremely hydrophobic and shed water almost totally. A moisture absorption of <0.03% has been reported after 24 hr in water at room temperature, followed by 2 hr in boiling water. They are also virtually unaffected by oxygen, ozone, and visible or UV light.

Test samples, exposed for many years to practically all climatic conditions, have shown that fluoropolymers are fully weather-resistant. Results show neither aging nor embrittlement. Because no plasticizers, antioxidants, or other additives are used during its processing, there is no leaching of substances.

Chemours™ fluoropolymers are essentially nonflammable. They will sustain combustion only in an environment containing >95% oxygen (Limiting Oxygen Index). Heat of combustion is extremely low at 5 kJ/g (for ETFE, 12.5 kJ/g); this provides an additional safety advantage, as the "fuel-load" or energy contained in the material that could be released in a fire event is very low.

For comparison, the heat of combustion of polyethylene is 46 kJ/g; therefore, PE will generate more heat in a fire situation and propagate a fire contrary to fluoropolymers (which are self-extinguishing). Flame propagation and rate of heat release of Chemours™ fluoropolymers are low. These properties make fluoropolymers, in particular, useful in applications where fire hazards must be kept to a minimum.
## Typical Properties of Chemours™ Fluoropolymers

<table>
<thead>
<tr>
<th>Typical Property</th>
<th>Test Method</th>
<th>Units</th>
<th>Teflon™ PTFE Fine Powder</th>
<th>Teflon™ FEP</th>
<th>Teflon™ PFA</th>
<th>Tefzel™ ETFE</th>
<th>ECCtreme™ ECA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ISO 1183 ASTM D792</td>
<td></td>
<td>2.15</td>
<td>2.15</td>
<td>2.15</td>
<td>1.70</td>
<td>2.16</td>
</tr>
<tr>
<td>Melting Point (2nd)</td>
<td>ASTM D3418</td>
<td>°C (°F)</td>
<td>327 (621)</td>
<td>255 (491)</td>
<td>305 (581)</td>
<td>270 (518)</td>
<td>317 (603)</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ISO 12086 ASTM D4895</td>
<td>psi</td>
<td>3,000</td>
<td>3,000</td>
<td>3,600</td>
<td>6,000</td>
<td>2,900</td>
</tr>
<tr>
<td>Elongation</td>
<td>ISO 12086 ASTM D4895</td>
<td>%</td>
<td>200</td>
<td>300</td>
<td>350</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>ISO 178 ASTM D790</td>
<td>psi</td>
<td>65,000</td>
<td>75,500</td>
<td>100,000</td>
<td>145,000</td>
<td>65,000</td>
</tr>
<tr>
<td>Temperature Rating</td>
<td>ISO 2578 ASTM D3045</td>
<td>°C (°F)</td>
<td>260 (500)</td>
<td>200 (392)</td>
<td>260 (500)</td>
<td>155 (311)</td>
<td>300 (572)</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>ASTM D150</td>
<td></td>
<td>2.03</td>
<td>2.03</td>
<td>2.03</td>
<td>2.6</td>
<td>2.05</td>
</tr>
<tr>
<td>Coefficient of Friction</td>
<td>ASTM D3702</td>
<td></td>
<td>0.05</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.05</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>ISO 4599 ASTM D543</td>
<td></td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

## Comparisons to Other Fluoropolymers

<table>
<thead>
<tr>
<th>Fluoropolymer</th>
<th>Typical Melting Point (°C)</th>
<th>Typical Upper Continuous-Use Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE</td>
<td>340</td>
<td>260</td>
</tr>
<tr>
<td>ECA²</td>
<td>317</td>
<td>300</td>
</tr>
<tr>
<td>PFA</td>
<td>305</td>
<td>260</td>
</tr>
<tr>
<td>FEP</td>
<td>260</td>
<td>205</td>
</tr>
<tr>
<td>ETFE</td>
<td>255-280</td>
<td>150</td>
</tr>
</tbody>
</table>

1. The continuous service temperature is based on accelerated heat-aging tests and represents the temperature at which tensile strength and ultimate elongation retain 50% of the original values after 20,000 hr thermal aging. Continuous service temperature above those listed may be feasible, depending on such factors as chemical exposure, support from the substrate, etc. When considering uses of Teflon™ fluoropolymer materials, preliminary testing should be done to verify suitability.

2. UL Yellow Card (E54681) for 300 °C (572 °F) rating is based on UL 746B testing; for wire and cable applications, 300 °C (572 °F) rating is referenced in UL 1581 and UL 758. Not a guarantee of performance; see section “Important Notice” on ECCtreme™ ECA product information sheets.

UL has recognized ECCtreme™ ECA with a Yellow Card for 300 °C (572 °F), and ECCtreme™ ECA has achieved the highest Relative Thermal Index value in UL’s Plastics Component Database.
Compared to fully and partially fluorinated fluoropolymers, ECCtreme™ ECA fluoropolymer resins demonstrate the highest combination of temperature and chemical resistance.

ECCtreme™ ECA fluoropolymer resins demonstrate the superior abrasion resistance of PTFE when compared to other melt processable fluoropolymer materials.
THE ECCTREME™ ECA FAMILY OF PRODUCTS

A range of products to meet all of your design and performance needs

**Extruded sheet lining for tanks and vessels, extruded tube and pipe, and compression and transfer molded parts**

- **MFR:** 3 g/10 min
- **Peak Melting Temperature:** 317 °C (603 °F)
- **Flex Life Before Heat Exposure:** 150,000 cycles
- **Flex Life After Heat Exposure:** >1,000,000 cycles

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**Large gauge wire insulations, extruded tubing, and compression, transfer, and injection molded parts**

- **MFR:** 7 g/10 min
- **Peak Melting Temperature:** 317 °C (603 °F)
- **Flex Life Before Heat Exposure:** 15,000 cycles
- **Flex Life After Heat Exposure:** 140,000 cycles

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**Extruded sheet lining for tanks and fine wire insulations, extruded thin film, and injection molded parts**

- **MFR:** 14 g/10 min
- **Peak Melting Temperature:** 317 °C (603 °F)
- **Flex Life Before Heat Exposure:** 4,000 cycles
- **Flex Life After Heat Exposure:** 12,000 cycles

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Heat-exposed ECCTREME™ ECA plaques were placed in a 300 °C (572 °F) air convection oven for 7 days before testing.
ECCTreme™ ECA shows no degradation of tensile modulus properties after nearly 2 years of constant 315 °C (599 °F) heat exposure.

Even after prolonged 300 °C (572 °F) heat exposure, parts molded from ECCTreme™ ECA not only retain physical properties, but internal studies indicate that prolonged heat exposure can actually lead to improvements in some mechanical properties.

Historically, typical perfluoropolymers have had an upper continuous-use temperature of only 260 °C (500 °F).

Parts made from ECCTreme™ ECA fluoropolymer resins demonstrate exceptional performance at high temperatures where other melt-processable materials fail.
## INCREASED PERFORMANCE IN WIRE AND CABLE

### ECCtreme™ ECA Electrical Performance

<table>
<thead>
<tr>
<th></th>
<th>Dielectric Constant¹</th>
<th>Dissipation Factor²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 Hz</td>
<td>1 MHz</td>
</tr>
<tr>
<td>ECCtreme™ ECA 3000 Control</td>
<td>2.05</td>
<td>2.05</td>
</tr>
<tr>
<td>ECCtreme™ ECA 3000 After 7 days at 300 °C (572 °F) Heat Exposure</td>
<td>2.05</td>
<td>2.05</td>
</tr>
</tbody>
</table>

¹Dielectric constant precision was typically +/- 1%.
²Dissipation factor precision was typically +/- 0.00002.

### ECCtreme™ ECA Dielectric Strength

<table>
<thead>
<tr>
<th></th>
<th>Average Specimen Thickness (mm)</th>
<th>Test Value (kV)</th>
<th>Converted Value (kV/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECCtreme™ ECA 3000 Control</td>
<td>2.793</td>
<td>49.6</td>
<td>17.7</td>
</tr>
<tr>
<td>ECCtreme™ ECA 3000 After 10,080 hours at 310 °C (590 °F) Heat Exposure</td>
<td>2.922</td>
<td>50.2</td>
<td>17.2</td>
</tr>
</tbody>
</table>

Retains 97% of dielectric strength after 14 months at 310 °C (590 °F) heat exposure

ECCtreme™ ECA has a dielectric constant similar to other melt-processable perfluoropolymers and a dissipation factor lower than standard PFA. After 14 months of heat exposure at 310 °C (590 °F) (10 degrees above its upper use temperature), ECCtreme™ ECA retained 97% of its electrical properties.

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Testing was performed using the guidelines set forth in ASTM D150, "Standard Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials". A parallel-plate test fixture having a 2-inch diameter guarded electrode was utilized to conduct the tests.

ASTM D3307 specifies ASTM D150 for determining dielectric constant and dissipation factor.
**INCREASED STRESS CRACK RESISTANCE**

Unlike other fluoropolymers, ECCtreme™ ECA does not break down after exposure to extreme heat for extended periods of time. In some instances, ECCtreme™ ECA has been observed to show increased physical property performance after heat exposure. The melt flow rate (MFR) of ECCtreme™ ECA decreases with heat exposure, which is indicative of the co-crystallization effect. Also unique to ECCtreme™ ECA is that, typically, an increase in crystallinity can lead to a brittle or rigid material that would be prone to stress cracking.

Interestingly, even after ECCtreme™ ECA is exposed to heat well above its 300 °C (572 °F) upper use temperature, the MIT flex life of the material actually increases over time as a result of end-to-end coupling.

![MFR Shift with 300 °C (572 °F) Heat Exposure](image)

![Flex Life Increase with 315 °C (599 °F) Heat Exposure](image)
MECHANICAL PROPERTY RETENTION

Even after exposure to 300 °C (572 °F) diesel fuel, plaques made from ECCtreme™ ECA have the same excellent chemical resistance as virgin material.

Heat-treated ECCtreme™ ECA plaques were placed in a 300 °C (572 °F) air convection oven for 7 days before exposure.
ECCtreme™ ECA outperforms high permeation-resistant Teflon™, for example, PTFE 7A X and PFA 951HP Plus, in gas permeation. Remarkably, ECCtreme™ ECA exhibits a greater than 50% increase in relative permeation resistance after heat exposure.

Increased crystallinity after heat exposure improves the gas permeation resistance of ECCtreme™ ECA in both CO₂ and oxygen, which are representative of common industrial gases.

Along with excellent chemical and steam resistance, the unique co-crystallization effect of ECCtreme™ ECA increases its permeation resistance to concentrated HCl, giving it the ability to perform as well as or better than the leading materials of the Teflon™ PFA product line, which are widely recognized as industry-leading materials for permeation resistance.
CHEMICAL RESISTANCE

Fluoropolymers are virtually inert to the most aggressive organic and inorganic chemicals and solvents over a wide temperature range. Chemical inertness means that ECCtreme™ ECA fluoropolymers can be in continuous contact with another substance with no detectable chemical reaction or degradation taking place. Among others, ECCtreme™ ECA is resistant to fuming sulfuric and nitric acids, bases, aggressive peroxides, antioxidants (as used in high temperature oils), and methanol (as used in fuel). This nearly universal chemical compatibility stems from three causes:

- Very strong inter-atomic bonds between C-C and C-F atoms
- Almost perfect shielding of the carbon backbone by fluorine atoms
- Very high molecular weight compared to many other plastics

ECCtreme™ ECA fluoropolymer resins demonstrate improved chemical permeation resistance after prolonged 300 °C (572 °F) heat exposure.
CHEMICAL RESISTANCE (cont'd.)

Within normal use temperatures, ECCtreme™ ECA fluoropolymer resins are compatible with virtually all chemical reagent systems. The only materials known to react with fluoropolymers are:

- Elemental alkali metals like sodium, potassium, and lithium (molten or in solution)
- Extremely potent oxidizers, fluorine (F₂) and related compounds like chlorine trifluoride (ClF₃)
- 80% NaOH or KOH solutions at or near the upper service temperature
- Intimate blends of finely divided metal powders (e.g., aluminum or magnesium) with powdered fluoropolymers can react violently when ignited; but, ignition temperatures are far above the published recommended maximum service temperature for fluoropolymers

Organic solvents do not attack or dissolve fluoropolymers, although some permeation may occur as a result of both absorption and diffusion. Strong oxidizing acids, organic bases, and sulfonic acids at high concentrations and near their boiling point may affect ECCtreme™ ECA resins.

Parts molded from ECCtreme™ ECA fluoropolymer resins are unaffected by exposure to high pressure steam, a common enemy of many fluoropolymers.
PROCESSING TECHNIQUES AND POTENTIAL APPLICATIONS

Validated Processing Technologies

- Tubing
- Compression molding
- W&C extrusion (power and data cables)
- Injection molding
- Film/sheet
- Transfer molding

Target Industries

- Oil and gas
- Geothermal
- Chemical processing industry
- Pulp and paper

New Applications

- Fine wire having 2-10 mil of insulation on AWG 40 to AWG 16 wire
- Smaller wire constructions than previously obtained with ECCtreme™ ECA resins demonstrated at 2 mil on AWG 36
- Higher melt flow ECCtreme™ ECA allows for injection molding of fine parts
- ECCtreme™ ECA 2000 (MFR = 2) has allowed for new application development in transfer molding, extruded sheet, and tubing
COMPOUNDED WITH VARIOUS FILLERS

ECXtreme™ ECA has been successfully compounded with:

- Carbon fiber (chopped and milled)
- Carbon black
- Fiber glass
- Mica
- Aramid fibers
- Ceramic microspheres
- Titanium dioxide
- Color concentrates
For more information, visit teflon.com/industrial

For sales and technical contacts, visit teflon.com/industrialglobalsupport

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