



Dyneon™
Polytetrafluoroethylene
Product Comparison Guide



3M *Innovation*

Dyneon™ PTFE

The unique properties of polytetrafluoroethylene (PTFE) have made it an indispensable material for a broad and ever-growing list of industries and applications. Whether your design requires extreme chemical resistance, a very wide service temperature range, a low coefficient of friction, non-stick properties or an extended service life, Dyneon has a material for you. In fact, we offer the widest range of virgin and compounded grades available.

And, with fully accredited laboratories and a global staff of application and product design engineers and scientists, we can provide not only the material you need, but also the technical expertise to help you optimize it in your application and manufacturing process.

Please contact us at one of the numbers shown on the back cover to locate the Dyneon technical representative nearest you.



A Broad Range of Applications

PTFE has become the material of choice where low friction, excellent thermal properties, chemical inertness, and exceptional dielectric properties are required. Dyneon™ PTFE continues to meet tough demands for new applications and maintains proven success and high reliability in the following industries:

Automotive

PTFE and PTFE compounds are used in seals, self-lubricating bearings and other sliding elements. The chemical resistance of PTFE provides long service life in the presence of fuels, lubricants and other harsh environments. The wide service temperature range makes PTFE ideal for high temperature applications near hot-running parts as well as very cold environmental temperatures. In addition, PTFE compounded with fillers can achieve exceptional wear resistance in dynamic and static components such as seals.

Chemical Processing

The chemical and thermal resistance of PTFE, as well as its low coefficient of friction, make it an ideal material for corrosion-resistant equipment in chemical processing plants. PTFE can be used to coat or line vessels and pipes, to seal interfaces, and to protect a variety of equipment from chemical and thermal attack. Other proven applications include pump and valve components, diaphragms, tubing, gaskets, seals, and process control apparatus.

Coatings

The non-stick and heat-resistant properties of PTFE have made it a useful coating material for cookware, bakeware, utensils, small appliances and industrial components. Dyneon manufactures and sells PTFE powders and aqueous-based dispersions of PTFE that can be formulated into many types of coatings.

Construction

PTFE dispersions are often used to coat and impregnate woven fiberglass and other heat resistant fabrics and fibers requiring chemical resistance, weather resistance, and heat resistance. These coated and impregnated fabrics can be applied as roofings, tents, domes and other architectural membranes that allow free form design. PTFE-coated fabrics are virtually self-cleaning, have good light transmission, and don't support combustion.

Electrical and Electronic

The exceptional dielectric strength and low electrical loss properties of PTFE make it useful as insulation for wire and cable constructions. The high thermal stability and flame resistance are also very desirable in electronic and electrical applications.

Semiconductor Manufacturing

Dyneon offers ultra high purity (UHP) grades of PTFE with extremely low levels of anions and metal extractables. PTFE is used for many parts in wet chemical process equipment to provide increased chemical resistance while maintaining extremely high purity within the system. The smooth surfaces possible from machined PTFE provide for easy cleaning and rinsing as well as fast drying.

Dyneon™ PTFE - Product Forms

The Dyneon™ PTFE family of products is offered in the following forms:

Granular Resins

Dyneon™ standard grades of granular PTFE and modified grades of TFM™ PTFE are available in both “standard-flow” and “free-flow” versions so that processors can select the degree of flowability that is appropriate to their processing technique. These materials are typically used for the manufacture of finished parts with complex shapes or semi-finished parts such as billets, rods, tubes and sheets.

Granular resins are also available as an extensive line of filled materials. Dyneon™ Custom PTFE Compounds are developed using a broad range of additives such as glass, carbon, bronze, pigments and other polymers. Filled systems are often used to increase wear resistance, especially in sealing applications. Special formulations can be tailored to meet the demanding requirements of practically any PTFE application.

Fine Powders

Dyneon manufactures and sells a broad line of fine powder PTFE grades for paste extrusion processes. Various grades are tailored for extrusion of wire and cable insulation, tapes, tubes, liners and profiles. Dyneon’s line of fine powders includes standard grades of unmodified PTFE as well as modified grades of TFM™ PTFE.

Micropowders

Dyneon’s micropowder products are characterized as having low molecular weight and very fine particle size, and are most often used as additives to improve slip and non-stick characteristics. You can find Dyneon™ Micropowders in thermoplastics, inks, lubricants, and paint and coating systems.

Dispersions

Dyneon supplies a variety of aqueous dispersions that can be used for cloth coating, impregnation of yarns and fibers, and formulation of metal coating systems. Dyneon™ PTFE Dispersions improve the weatherability, chemical-resistance, heat-resistance and anti-stick properties of the substrate.



Dyneon™ PTFE Forms and Applications

Granular Resins

Standard-Flow and Free-Flow Grades
Standard-Flow and Free-Flow Modified Grades
Standard-Flow and Free-Flow Custom Compounds based on standard or modified resin

Typical Applications:

Finished or semi-finished parts: sheets, rods, tubes, billets for skiving of films or machining into complex shapes

Fine Powders

Standard Grades
Modified Grades

Typical Applications:

Paste extrusion of film/tape, expanded tape, electrical insulation, tubing, pipe liners, profiles, and fibers

Dispersions

Stabilized Aqueous-Based Emulsions

Typical Applications:

Coating of woven fiberglass cloth, impregnations of fibers and yarns and formulation of metal coating systems

Micropowders

Variety of Grades and Manufacturing Technologies

Typical Applications:

Additives to improve slip or wear characteristics in ink, plastics, and lubricants

Dyneon™ PTFE Virgin Granular Grades and Selected Compounds

Typical Properties (Not for specification purposes)

Powder Properties	Test Conditions	Unit	Test Method	TFM™ PTFE			Unmodified PTFE					Selected Compounds													
				TFM 1700 ⁽²⁾⁽³⁾	TFM 1705 ⁽²⁾⁽³⁾	TFM 1600 ⁽²⁾⁽³⁾	TF 1750 ⁽²⁾⁽³⁾	TF 1620 ⁽²⁾⁽³⁾	TF 1641 ⁽²⁾⁽³⁾	TF 1645 ⁽²⁾⁽³⁾	TFR 1105 ⁽²⁾⁽³⁾	TF4103	CC603	CC605	CCM605	CCX1029	CC503 ⁽³⁾	CC622	CC646/S	CC655	CC174/N	CC191-HE	CCX6380	CC085	
ASTM Classification			ASTM D 4894 ⁽¹⁾	type III, grade 1	type III, grade 1	type III, grade 2	type II	type IV, grade 2	type IV, grade 2	type IV, grade 2	N/A	type II	type II	type II	type II	type I	type II	type II	type II	type II	type II	type I	type I	type II	type I
Powder Flow Properties				non-free-flowing	non-free-flowing	very good free-flowing	non-free-flowing	limited free-flowing	very good free-flowing	very good free-flowing	very good free-flowing	very good free-flowing	free-flowing	free-flowing	free-flowing	non-free-flowing	free-flowing	free-flowing	free-flowing	free-flowing	free-flowing	non-free-flowing	non-free-flowing	free-flowing	non-free-flowing
Average Particle Size		µm	ASTM D 4894 ⁽¹⁾	25	25	450	25	220	450	450	800	600	750	750	750	25	750	750	750	750	750	25	25	750	25
Filler			—	—	—	—	—	—	—	—	—	glass fiber	glass fiber	glass fiber	glass fiber/TFM™ PTFE	carbon fiber	mineral	graphite	bronze	stainless steel	fiberglass/moly	carbon/graphite	polyimide	PPS	
Filler Content		wt. %	ASTM E 1131	—	—	—	—	—	—	—	—	15	15	25	25	10	15	10	60	50	15/5	23/2	10	proprietary	
Bulk Density		g/l	ASTM D 4894 ⁽¹⁾	420	420	830	370	850	830	830	820	820	720	730	710	475	685	650	1200	1100	520	440	580	375	
Mechanical Properties																									
Specific Gravity		g/cm ³	ASTM D 4894 ⁽¹⁾	2.16	2.16	2.16	2.16	2.15	2.15	2.15	2.16	2.21	2.20	2.22	2.24	2.08	2.26	2.14	3.92	3.33	2.27	2.00	2.00	1.95	
Tensile Strength		psi	ASTM D 4894 ⁽¹⁾	4800	4800	4600	4000 min	4000 min	4000 min	4000 min	4000	3000	3000	2500	2200	4000	2800	2800	2400	3000	3400	2000	2700	1600	
Tensile Elongation		%	ASTM D 4894 ⁽¹⁾	450	450	450	350	350	350	350	400	375	280	230	300	280	250	220	110	220	240	160	270	150	
Tensile Modulus		psi	ASTM D 638	94,250	94,250	94,250	87,000	87,000	87,000	87,000	94,250	14,000	13,500	23,000	24,000	17,500	17,500	19,000	35,500	25,500	22,000	31,500	14,000	10,000	
Shore Hardness (D)	Initial		ASTM D 2240	62	62	62	62	62	62	62	62	62	62	62	62	66	65	62	71	71	66	68	59	66	
	15 second			58	58	58	58	58	58	58	58	57	57	57	57	60	60	56	65	65	60	63	53	61	
Deformation Under Load	2175 psi - 24 hrs.	%	ASTM D 621	4	4	3	8	7	7	7	4	6	7	7	2	5	5	6	4	5	5	4	5	2	
	2175 psi - permanent			2	2	2	4	4	4	4	2	4	4	3	1	3	3	3	2	3	3	2	3	1	
Shrinkage		%	ASTM D 4894 ⁽¹⁾	5.8	5.8	3.5	4.3	3	2.8	2.6	5.5	2.2	1.9	1.6	2.8	1.4	3.5	2.3	2	1.6	1.9	1.7	2.4	2.4	
Thermal Properties																									
Thermal Conductivity	@100°C	W/m*K	ASTM E 1530	0.22	0.23	0.23	0.30	0.31	0.31	0.31	0.23	0.26	0.32	0.29	0.24	0.29	0.34	0.39	0.47	0.40	0.26	0.36	0.20	0.36	
	@250°C			0.23	0.24	0.24	0.31	0.32	0.32	0.32	0.24	0.27	0.30	0.30	0.26	0.31	0.30	0.39	0.39	0.39	0.39	0.27	0.37	0.22	0.39
Coefficient of Thermal Expansion	86 - 212°F (30 - 100°C)	in / (in °F)	ASTM E 831	5.7	5.9	5.7	6.5	6.5	6.5	6.5	6.2	5.7	5.7	5.0	4.1	6.9	5.5	6.1	4.2	4.6	5.6	4.9	6.0	5.3	
	212 - 392°F (100 - 200°C)	x 10 ⁻⁵		7.5	7.7	7.5	8.7	8.7	8.7	8.7	8.1	7.7	7.7	6.8	6.1	9.8	7.3	8.1	6.2	6.3	7.6	6.6	7.7	7.8	
	392 - 500°F (200 - 300°C)			9.2	9.3	9.2	11.0	11.0	11.0	11.0	9.9	9.5	9.5	8.4	7.8	12.4	8.9	10.0	7.8	7.8	9.5	8.0	9.6	9.2	
Dielectric Strength		kV/mil	ASTM D 149	3.7	3.7	2.6	3.5	2.5	2.5	2.5	3.7	—	—	—	—	—	—	—	—	—	—	—	—	—	

Footnotes

⁽¹⁾ ASTM D 4894 used for virgin granular grades. ASTM D 4745 used for compounds.

⁽²⁾ Resin meets requirements set forth by the 3A Sanitary Standard for multiple-use plastic materials and the USP class VI test for plastic.

⁽³⁾ These products comply with 21 CFR 177.1550 and may be used as articles or components of articles intended to contact food subject to the provisions, including specifications, conditions of use, and limitations, if any, in this regulation. Dyneon makes no recommendation about the suitability of these products in the user's intended application. It is user's responsibility to determine whether its use of Dyneon products in a particular application is suitable and will comply with applicable laws and regulations.

Dyneon™ TFM™ PTFE

Modified for Improved Performance and Design Flexibility

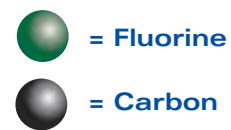
Dyneon™ TFM™ PTFE is a modified PTFE which bridges the gap between conventional PTFE and melt-processable PFA.

Dyneon™ TFM™ PTFE offers significantly improved properties over standard PTFE, such as:

- substantially lower deformation under load
- denser polymer structure
- lower permeability
- smoother surfaces
- higher transparency
- weldability to itself and to PFA

Dyneon™ TFM™ PTFE opens up new design possibilities, processing options and applications. It is ideal for end-uses requiring high standards of reliability, such as in automotive systems and plant and process equipment in the chemical, petroleum, and semiconductor industries.

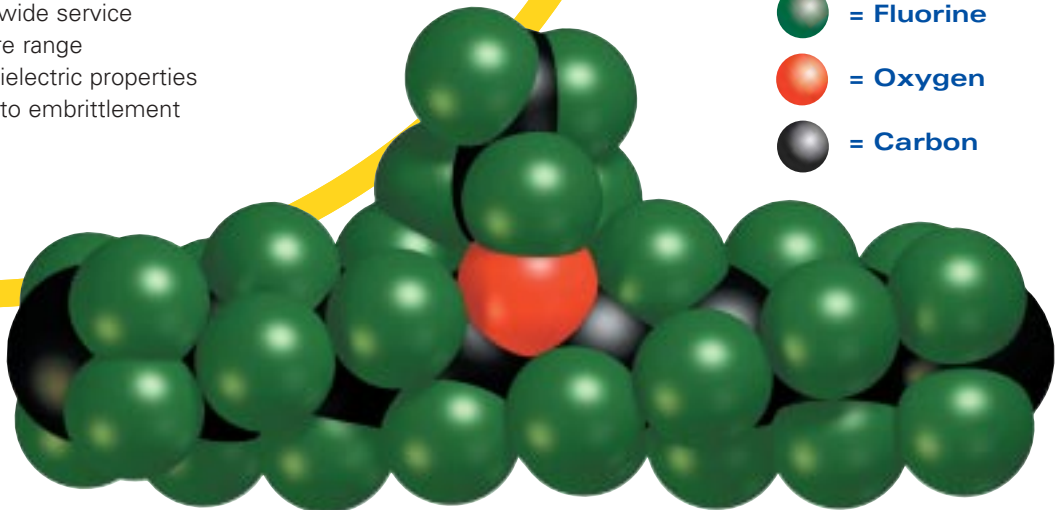
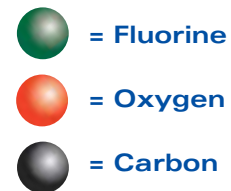
Molecular structure of conventional, unmodified PTFE



At the same time, Dyneon™ TFM™ PTFE retains the proven properties of PTFE:

- nearly universal chemical resistance
- extremely wide service temperature range
- excellent dielectric properties
- resistance to embrittlement and aging

Molecular structure of TFM™ PTFE



Dyneon™ PTFE Fine Powders (Paste Extrusion Grades)

Typical Properties (Not for specification purposes)

Powder Properties	Unit	Test method	TFM™ PTFE		Unmodified PTFE				
			TFM 2001	TF 2021	TF 2025	TFX 2035	TF 2029	TF 2071	TF 2072
ASTM Classification	ASTM D 4895		type I	type I	type I	type I	type I	type I	type I
Bulk Density	g/l	DIN 53466	450	510	510	470	480	510	500
Average Particle Size	µm	ASTM D 4895	500	500	500	500	500	500	600
Extrusion Pressure at RR ⁽¹⁾ 400	psi	ASTM D 4895	3770	4350	5800	5200	7250	-	-
at RR 1600	psi	ASTM D 4895	-	-	-	-	-	7685	5800
min. RR		Internal Dyneon method	20	20	20	15	5	20	50
max. RR		Internal Dyneon method	1000	500	300	300	100	1600	3000

Mechanical Properties, measured at 23°C on sintered moldings

Specific Gravity	g/cm ³	ASTM D 4895	2.15	2.15	2.15	2.17	2.15	2.16	2.16
Tensile Stress at Break	psi	ASTM D 4895	4930	4060	4060	4750	4060	4060	4060
Test Specimen Thickness	in	ASTM D 4895	.063	.063	.063	.063	.063	.063	.063
Elongation at Break	%	ASTM D 4895	400	340	340	435	340	360	360

Electrical Properties, measured at 23°C

Volume Resistivity	Ω · cm	IEC 60093		10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁸
Surface Resistance	Ω	IEC 60093		10 ¹⁷	10 ¹⁷	10 ¹⁷	10 ¹⁷	10 ¹⁷	10 ¹⁷

Typical Applications

High performance tubing. High pressure resistance under surge stress. Polymer structure with lower permeability.

Unsintered tapes, sealing cords.

Liners, tapes, yarns, thick wall tubing.

Liners, extruded tape, thick wall tubing.

Electrical insulating tapes, liners, yarns.

Tubing, wire and cable insulation, "spaghetti" tubing.

Very high reduction ratio extrusions, wire and cable insulation, "spaghetti" tubing.

Footnotes

⁽¹⁾ RR = reduction ratio

Dyneon™ PTFE Dispersions

Typical Properties (Not for specification purposes)

Properties (Average Values)	Unit	Test Method	TF 5032	TF 5035	TF 5039	TF 5041	TF 5050 (bimodal)	TF 5060	TF 5065	TF 5235
Solids Content	%	ASTM D 4441	60	58	55	60	58	60	59	62
Emulsifier Type			non-ionic	non-ionic	non-ionic	non-ionic	non-ionic	non-ionic	non-ionic	non-ionic
Emulsifier Content (Based on Solids Content)	%	ASTM D 4441	5	5	10	8	5	6	9	4
pH	–	ASTM D 4441	8.5	8.5	8.5	9	9	9	9	9
Viscosity	mPa·s	DIN 54 453 D = 30 s ⁻¹	22	14	18	47 ⁽¹⁾	10	22	25	28
Density	g/cm ³	hydrometer	1.5	1.5	1.4	1.4	1.5	1.5	1.5	1.6
Particle Size PTFE	nm	ISO 13321	160	225	225	225	220	220	220	225

Typical Applications	TF 5032	TF 5035	TF 5039	TF 5041	TF 5050 (bimodal)	TF 5060	TF 5065	TF 5235
	Impregnation.	Formulation of coating systems.	Coating of glass fiber fabrics.	PTFE dispersion with micro glass spheres for membrane structures.	Formulation of coating systems. Impregnation.	Coating of glass fiber fabrics.	Coating of glass fiber fabrics.	Formulation of coating systems. Impregnation.

Footnote

⁽¹⁾ Viscosity measured at D = 1000 s⁻¹.

Dyneon™ PTFE Micropowders

Typical Properties (Not for specification purposes)

Powder Properties	Unit	Test Method	TF 9201	TF 9205	TF 9207	J14	J24
Polymer Type			Emulsion	Suspension	Emulsion	Emulsion	Suspension
Manufacturing Method			Direct Polymerization	Thermal Degradation	Direct Polymerization	E-Beam Irradiation	E-Beam Irradiation
Average Particle Size	µm	laser diffraction	6	8	4	6	15
Primary Particle Size	nm	laser diffraction	200	–	120	200	-
Bulk Density	g/l	ISO 12086	350	400	280	260	400
Specific Surface Area BET	m ² /g	DIN 66131 DIN 66132	10	2	17	-	-
Melting Peak Temperature	°C (°F)	ASTM D 4591-97	330 (626)	325 (617)	329 (624)	322 (612)	327 (621)
Melt Flow Rate MFR ⁽¹⁾	g/10 min	ISO 11331	<2	12	6	-	-
Food Contact/Regulatory Status		FDA ⁽²⁾ EU ⁽³⁾	Yes Yes	No Yes	Yes Yes	No No	No No

Typical Applications

- not recommended + recommended ++ good experience

Lubricants/Additives

Silicone Oils

+ + + ++ +

Engine Oils

+ – + ++ +

Greases

+ + + ++ +

Printing inks

– ++ + + –

Non-Stick and Antifriction Coatings

– ++ ++ ++ +

Non-Stick and Antifriction Sprays

+ – + ++ –

Dry Lubricants

+ + ++ ++ +

Footnotes

⁽¹⁾ The measurements are carried out at 372°C (702°F) with different test weights and nozzle diameters. (TF 9201 - 10kg - 2.095mm, TF 9205 - 2.16kg - 1.0mm, TF 9207 - 2.16kg - 2.095mm) The melt viscosity of micropowders can be calculated from the melt flow rate (MFR) by Hagen-Poiseuille's law to obtain an indication of molecular weight. The molecular weight of the micropowder products increases in the following order: J-14, TF 9205, J-24, TF 9207, TF 9201.

⁽²⁾ This product complies with 21 CFR 177.1550 and may be used as articles or components of articles intended to contact food subject to the provisions, including specifications, conditions of use, and limitations, if any, in this regulation. Dyneon makes no recommendation about the suitability of these products in the user's intended application. It is user's responsibility to determine whether its use of Dyneon products in a particular application is suitable and will comply with applicable laws and regulations.

⁽³⁾ It is hereby certified that monomers used for the production of the above-mentioned product supplied by Dyneon are listed in the EU-Directives 90/128/EEC, 92/39/EEC, 03/9/EEC, 95/3/EC, 96/11/EC, 1999/91/EC about materials and articles made of plastics and intended to come into contact with foodstuffs or toys and in the "German Bedarfsgegenständeverordnung" of April 10th, 1992 as hereafter including December 21st, 2000.

Imaginative fluoropolymer solutions

At Dyneon, our goal is to provide you with design solutions to make your job easier – helping you with expert material selection advice now so that you can avoid problems later.

Whatever your challenge, you can count on Dyneon to respond with dependable, high-performance fluoropolymer products. By working directly with our customers and exploring new technologies, you can be sure that our fluoropolymers will not only meet today's needs, but future design requirements as well.

Our worldwide commitment to quality

Indicative of our commitment, most Dyneon design, development, production and service facilities have achieved a global ISO 9001 quality management certification. One of our Decatur, Alabama sites and all Germany locations, as well as the production facilities at Antwerp, Belgium have also received ISO 14001 certification for their environmental management system. And, our Aston, Pennsylvania PTFE custom compounding facility has A2LA accreditation for its quality control laboratory.

The Dyneon Product Portfolio:

Dyneon™

PTFE Resins, TFM™ PTFE, Custom PTFE Compounds
PTFE Fine Powders
PTFE Dispersions
PTFE Micropowders

Dyneon™

PFA, ETFE, FEP, HTE,
PVDF, THV™ Fluoroplastics

Dyneon™

Fluoroelastomers

Dynamar™

Polymer Processing Additives

Dyneon™

Polymer Additives

Dynamar™

Elastomer Additives

Dyneon™

Monomers

Important Notice:

Because conditions of product use are outside Dyneon's control and vary widely, user must evaluate and determine whether a Dyneon product will be suitable for user's intended application before using it. **The following is made in lieu of all express and implied warranties (including warranties of merchantability and fitness for a particular purpose): If a Dyneon product is proved to be defective, Dyneon's only obligation, and user's only remedy, will be, at Dyneon's option, to replace the quantity of product shown to be defective when user received it or to refund user's purchase price. In no event will Dyneon be liable for any direct, indirect, special, incidental, or consequential loss or damage, regardless of legal theory, such as breach of warranty or contract, negligence, or strict liability.**

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