Fluropolymer Overview & Selection Guide

Fluoropolymer Family

A group of plastics where the molecules contain carbon and fluorine which dramatically change the properties to include: very high working temperatures, no-stick characteristics, very high resistance to chemicals and solvents, and very high electrical resistance.

F *fluorine* Fluorine typically imparts chemical resistance, thermal stability, and low surface energy. Fluoro Intermediates are used as the key building blocks require fluoropolymers.

TFE *tetrafluoroethylene* TFE is the key per fluorinated monomer used to produce a wide range of fluoropolymers. Most Teflon® film branded fluoropolymer products are derived from TFE. This monomer can also be used to add fluorinated functionality to a variety of hydrocarbon precursors. For example, a fluorinated ether can be synthesized through nucleophilic addition of an alkoxide across the double bond of TFE.

Fluoropolymer Selection Guide					
Polymer Reference	**Chemical Name**	**Mechanical**	**Thermal**	**Electrical**	**Chemical**
PTFE	***polytetrafluoroethylene***	Good dimensional stability. High rate of creep.	Excellent -180° to 260°C	Excellent	Excellent
FEP	***fluoroethylene-propylene***	Good dimensional stability. High rate of creep.	Excellent -190° to 205°C	Better	Excellent
PFA	***perfluoralkoxy***	Better. High rate of creep. Low resistance to abrasion.	Excellent -150° to 260°C	Better	Excellent
ETFE	***ethylene-tetrafluoroethylene-copolymer***	Excellent. High tensile strength and impact strength.	Better -100° to 150°C	Excellent	Good
ECTFE	***ethylene-chlorotrifluoroethylene***	Excellent abrasion resistance.	Better Maximum continuous use at 150°C	Excellent	Excellent
PCTFE	***polychloro-trifluoroethylene***	Excellent low creep.	Better -250° to 150°C	Good	Excellent

Comparative For Fluorocarbon Resins							
Property	**Modified PTFE**	**PFA**	**FEP**	**ETFE Tefzel®**	**ECTFE Halar®**	**PVF Tedlar ®**	**PCTFE**
Specific Gravity	2.15	2.16	2.15	1.70	1.68	1.77	2.13
Tensile Strength @ Brk., RT, %	5000	4500	3000	6500	7000	4500	4000
Elongation @ Brk., RT, %	400	300	290	150	200	50	140
Flex Strength, psi	No Brk.	N.A.	3000	7100	7000	9500	8600
Flexural Modulus, psi x 10^5	.7-1.1	1.0	0.9	2.0	2.4	2.5	1.5
Hardness (Shore, Rockwell)	D50-65	D60	D55, R45	D75, R50	D75, R95	R109	R109
Izod Impact Ft/Lbs/In - Notch, RT	3	No Brk.	No Brk.	No Brk.	No Brk.	4	1.2
Melt Point, ºF	627	575-590	500-535	520	465	340	394
Max. Oper. Temp., Continuous ºF	550	500	400	350	340	265	350
Low Temp. Embrittlement, ºF	-450	N.A.	-100	-150	-105	-80	-423
Deflection Temp., ºF @ 66 psi	250	N.A.	158	220	240	270	258
Deflection Temp., ºF @ 264 psi	120	N.A.	N.A.	160	170	195	N.A.
Thermal Expansion, 10^{-5}/In/ºC	10.0	12	9.5	7	8	8.5	7.2
Dielectric Strength, V/mil (.001")	4200	4000	6500	7000	2000	1280	3500
Dielectric Constant, 10^3 cycles	2.1	2.1	2.1	2.6	2.6	7.7	2.5
Dissipation Factor, 10^3 cycles	<.0003	.0002	<.0002	.0008	.0015	.018	.025
Water Vapor Permeability (ranked)	5	6	5	4	2	3	1 (best)
Chemical Resistance (ranked)	1	1	1	2-3	2	4	2
Coef. of Friction	1	2	3	4	4	5	5

PTFE *polytetrafluoroethylene* Basic PTFE is a linear polymer of TFE and is a true homopolymer. Virgin (pure) PTFE is the most unusual and exhibits the best performance in terms of temperature resistance, chemical resistance, and non-stick properties. Its major disadvantage is that it does not actually melt when heated and therefore is difficult to process, and very unconventional techniques are needed to mold, extrude and weld it.

Modified PTFE *polytetrafluoroethylene* Modified PTFE is made of a modified homopolymer PTFE resin containing some percentage of a fully fluorinated comonomer (usually PPVE). This chemically modified version of PTFE yields a material with improved electrical and physical properties over virgin PTFE. The result is a material that exhibits equivalent chemical resistance, increased tensile strength and greater elongation. Unlike virgin PTFE, conventional plastic techniques can be used to process this material (ie thermally bonding or fusing Modified PTFE to itself). Because of these properties Modified PTFE is often a lower cost alternative to other melt processable films (ie PFA and FEP). There are a variety of different resin manufacturers and different processor recipes available. **Modified PTFE is made from Dyneon TFM 1700 resin, DuPont NXT 70 resin or Daiken M-111 resin.**

TFM™ PTFE *polytetrafluoroethylene* TFM™ is a chemically modified PTFE resin manufactured by Dyneon™, with about 0.1% PPVE. TFM™ retains all the proven advantages of conventional PTFE plus it offers enhanced properties including: substantially lower deformation under load, lower permeation due to denser polymer structure and fewer voids, better weldability, improved stress recovery (particularly at elevated temperatures), smoother surface finishes, and higher transparency. **The most common brand name is Dyneon™ TFM™ PTFE resin.**

Teflon® is a Registered trademark of DuPont, Teflon® film has become a familiar household name, recognized worldwide for the superior non-stick properties associated with its use as a coating on cookware and as a soil and stain repellant for fabrics and textile products.The Teflon® film trademark was coined by DuPont and registered in 1945; the first products were sold commercially under the trademark beginning in 1946. Today, the family of fluoropolymers from DuPont consists of: PTFE, the original resin; FEP, introduced in 1960; Tefzel® ETFE film in 1970; and PFA, in 1972.

FEP *fluoroethylene-propylene* FEP was developed by DuPont as a Melt Processable Teflon® film which can be processed by normal plastic methods unlike virgin PTFE. With the same benefits as other fluoropolymers FEP has a lower maximum operating temperature of 392°F (200°C). The most common brand names include DuPont Teflon® FEP and Saint-Gobain Norton® FEP.

PFA *perfluoralkoxy* PFA was developed by DuPont as a High Temperature Teflon® with a maximum operation temperature of 500°F (260°C), while maintaining similar properties to other fluoropolymers. Of course this added temperature resistance also adds a significant increase in cost. PFA is a melt-processable thermoplastic with similar chemical resistance to PTFE, but has much lower porosity and is translucent. The most common brand names include DuPont Teflon® PFA and Saint-Gobain Norton® PFA.

ETFE *ethylene-tetrafluoroethylene-copolymer* ETFE was developed by DuPont as a Tough Teflon® with similar hardness compared to nylon, unlike virgin PTFE & FEP. The improvements in stiffness is paid for by reduced chemical resistance and working temperature. The most common brand name is **Tefzel ®** by Dupont

ECTFE *ethylene-chlorotrifluoroethylene* ECTFE is a tough fluoroplastic with similar properties to ETFE, but manufactured from Halar® resin resulting in superior chemical resistance. By far ECTFE film provides the highest abrasion resistance and highest dielectric strength of any fluoropolymer film. The most common brand name is **Halar® manufactured by Solvay Solexis**

PVDF ***polyvinylidene-fluoride*** PVDF is a high molecular weight thermoplastic polymer. PVDF is a very hard plastic roughly comparable to ECTFE, but relatively inexpensive in comparison to other fluoroplastics. Good chemical resistance, but not as good as ECTFE or ETFE. **The most common base resins are Kynar® manufactured by Elf Atochem North America or Solef® manufactured by Solvay S.A.**

PVF ***polyvinyl-fluoride*** PVF is also a very tough fluoroplastic with limited chemical and temperature resistance. Commonly used as a film in gas sampling bags, solar heating panels, and printing circuit laminating. **The most common brand names include DuPont Tedlar® PVF and Saint-Gobain Norton® PVF.**

PCTFE ***polychloro-trifluoroethylene*** PCTFE films are a line of film-based materials that are derived from high-performance resins and additional components used extensively in barrier applications. PCTFE films can be formulated to optimize a variety of attributes such as chemical resistance, moisture barrier, dielectric strength, thermal stability, optical clarity, coefficient of friction, and adhesion. PCTFE is available in basic shapes (plates & Rods) as manufactured through either extrusion or compression molding. PCTFE is also used extensively in pharmaceutical blister packaging for its chemical and moisture resistant properties where is goes by the trade name Aclar® (Clarus® for industrial applications). PCTFE films can be thermoformed into a variety of shapes and parts where clarity, moisture barrier, chemical resistance, heat stability, and dielectric properties of the film are not compromised. **The most common trade names include Kel-F ® (former trade name of 3M Performance Plastics), Daikin PCTFE (current resin used for most basic shapes), Honeywell Aclar® (used for films) and Honeywell Clarus®. Kel-F® is still the most commonly used brand name in the PCTFE market despite the fact that 3M discontinued PCTFE product in 1996.**