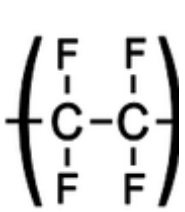


Polytetrafluoroethylene

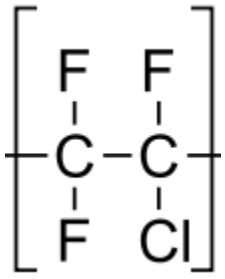
PTFE

TANNA Engineering Enterprises

Polytetrafluoroethylene (**PTFE**) is a synthetic fluoropolymer of tetrafluoroethylene that has numerous applications. The best known brand name of PTFE-based formulas is **Teflon** by DuPont Co., which discovered the compound. PTFE is a fluorocarbon solid, as it is a high-molecular-weight compound consisting wholly of carbon and fluorine. PTFE is hydrophobic: neither water nor water-containing substances wet PTFE, as fluorocarbons demonstrate mitigated London dispersion forces due to the high electro negativity of fluorine. PTFE has one of the lowest coefficients of friction against any solid. PTFE's mechanical properties can be enhanced by adding fillers such as glass fibers, carbon, graphite, molybdenum disulphide, and bronze. Generally, filled PTFE's maintain their excellent chemical and high temperature characteristics, while fillers improve mechanical strength, stability, and wear resistance. The properties of 25% glass-filled and 25% carbon-filled PTFE grades are shown below for comparison purposes.

TYPICAL PROPERTIES of PTFE

ASTM or UL test	Property	PTFE (unfilled)	PTFE (25% glass filled)	PTFE (25% carbon filled)
	PHYSICAL			
D792	Density (lb/in³) (g/cm³)	0.078 2.16	0.081 2.25	0.075 2.08
D570	Water Absorption, 24 hrs (%)	< 0.01	0.02	0.05
	MECHANICAL			
D638	Tensile Strength (psi)	3,900	2,100	1,900
D638	Tensile Modulus (psi)	80,000	-	-
D638	Tensile Elongation at Break (%)	300	270	75
D790	Flexural Strength (psi)	No break	1,950	2,300
D790	Flexural Modulus (psi)	72,000	190,000	160,000
D695	Compressive Strength (psi)	3,500	1,000	1,700
D695	Compressive Modulus (psi)	70,000	110,000	87,000
D785	Hardness, Shore D	D50	D60	D62
D256	IZOD Notched Impact (ft-lb/in)	3.5	-	-
	THERMAL			
D696	Coefficient of Linear Thermal Expansion (x 10^{-5} in./in./°F)	7.5	6.4	6
D648	Heat Deflection Temp (°F / °C) at 264 psi	132 / 55	150 / 65	150 / 65
D3418	Melting Temp (°F / °C)	635 / 335	635 / 335	635 / 335
-	Max Operating Temp (°F / °C)	500 / 260	500 / 260	500 / 260
C177	Thermal Conductivity (BTU-in/ft²-hr-°F) (x 10^{-4} cal/cm-sec-°C)	1.7 5.86	3.1 10.6	4.5 15.5
UL94	Flammability Rating	V-O	V-O	V-O
	ELECTRICAL			
D149	Dielectric Strength (V/mil) short time, 1/8" thick	285	-	-
D150	Dielectric Constant at 1 MHz	2.1	2.4	-
D150	Dissipation Factor at 1 MHz	< 0.0002	0.05	-
D257	Volume Resistivity (ohm-cm)at 50% RH	> 10^{18}	> 10^{15}	104



Polychlorotrifluoroethene

PCTFE

Polychlorotrifluoroethene (**PCTFE** or **PTFCE**) is a thermoplastic chlorofluoropolymerwith the molecular formula $(CF_2CClF)_n$, where n is the number of monomer units in thepolymer molecule. It is similar topolytetrafluoroethene (PTFE), except that it is ahomopolymer of the monomerchlorotrifluoroethylene (CTFE) instead of tetrafluoroethene. It has the lowest water vapor transmission rate of any plastic.

Applications –

PCTFE finds majority of its application due to two main properties; water repulsion and chemical stability. PCTFE films are used as a protective layer against moisture. These include,

- ✓ Moisture barrier in pharmaceutical blister packaging
- ✓ Water vapor barrier for protecting phosphor coatings in electroluminescent lamps. The phosphor chemicals are sensitive to moisture.
- ✓ To protect liquid crystal display (LCD) panels which are sensitive to moisture.

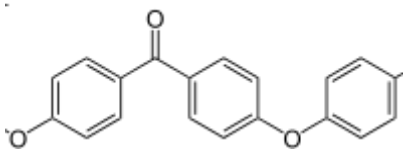
Due to its chemical stability, it acts as a protective barrier against chemicals. It is used as a coating and prefabricated liner for chemical applications. PCTFE is also used for laminating other polymers like PVC, polypropylene, PETG, APET etc. It is also used in transparent eyeglasses, tubes, valves, chemical tank liners, O-rings, seals and gaskets. PCTFE is used to protect sensitive electronic components because of its excellent electrical resistance and water repulsion. Other uses include flexible printed circuits and insulation of wires and cables. Low molecular weight PCTFE waxes, oils and greases find their application as inert sealants and lubricants. They are also used as gyroscope flotation fluids and plasticizers for thermoplastics.

PCTFE has high tensile strength and good thermal characteristics. It is non-flammable and the heat resistance is up to 175°C. It has a low coefficient of thermal expansion. The glass transition temperature (T_g) is around 45°C. PCTFE has the lowest limiting oxygen index (LOI).[16] It has good chemical resistance. It also exhibits properties like zero-moisture absorption and non wetting.

It does not absorb visible light. When subjected to high energy radiations, like PTFE, it undergoes degradation.[18] It can be used as a transparent film.

TYPICAL PROPERTIES OF PCTFE		
ASTM or UL test	**Property**	**PCTFE**
PHYSICAL		
D792	Density (lb/in³) (g/cm³)	0.077 2.13
D570	Water Absorption, 24 hrs (%)	< 0.01
MECHANICAL		
D638	Tensile Strength (psi)	5,300
D638	Tensile Modulus (psi)	207,000
D638	Tensile Elongation at Break (%)	150
D790	Flexural Strength (psi)	8,500
D790	Flexural Modulus (psi)	180,000
D695	Compressive Strength (psi)	5,500
D695	Compressive Modulus (psi)	180,000
D785	Hardness, Shore D	D90
D256	IZOD Notched Impact (ft-lb/in)	5
THERMAL		
D696	Coefficient of Linear Thermal Expansion (x 10^-5 in./in./°F)	7.0
D648	Heat Deflection Temp (°F / °C) at 264 psi	258 / 126
D3418	Melting Temp (°F / °C)	415 / 212
-	Max Operating Temp (°F / °C)	270 / 132
C177	Thermal Conductivity (BTU-in/ft²-hr-°F) (x 10^-4 cal/cm-sec-°C)	1.45 4.99
UL94	Flammability Rating	V-O
ELECTRICAL		
D149	Dielectric Strength (V/mil) short time, 1/8" thick	500
D150	Dielectric Constant at 1 MHz	-
D150	Dissipation Factor at 1 MHz	-
D257	Volume Resistivity (ohm-cm)at 50% RH	10^18

Polyetheretherketone

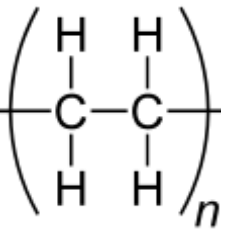


PEEK

Polyether ether ketone (PEEK) is a colorless organic thermoplastic polymer in the polyaryletherketone (PAEK) family, used in engineering applications. **PEEK (polyetheretherketone)** is a semi-crystalline, high-temperature (up to 500° F) engineering thermoplastic that is excellent for applications where thermal, chemical, and combustion properties (UL flammability rating of V-0) are critical to performance. At the same time, PEEK emits little smoke or toxic gas when exposed to flame. This material is tough, strong, and rigid and has superior creep resistance. It also resists radiation and a wide range of solvents. With its resistance to hydrolysis, PEEK can withstand boiling water and superheated steam used with autoclave and sterilization equipment at temperatures higher than 482° F. PEEK resins are available in unreinforced, 30% glass-fiber reinforced, 30% carbon-fiber reinforced, and HPV-reinforced grades. Typical applications include the automotive, marine, nuclear, oil-well, electronics, medical and aerospace industries.

TYPICAL PROPERTIES OF POLYETHERETHERKETONE (PEEK)

ASTM or UL Test	Property	Unreinforced	Glass Reinforced 20%	Glass Reinforced 30%	30% Carbon Reinforced
	PHYSICAL				
D792	**Specific gravity**	1.32	1.43	1.49	1.44
D792	**Specific volume** (in^3/lb)	21.0	19.3	18.6	—
D570	**Water absorption**, 24 h, 1/8-in thk (%)	0.5	—	0.11	0.06
	MECHANICAL				
D638	**Tensile strength** (psi)	13,300	17,800	22,800	30,200
D638	**Elongation** (%)	50	2.5	2.2	1.3
D638	**Tensile modulus** (10^5 psi)				
	At 302°F	1.6	—	—	—
	At 356°F	0.58	—	—	—
D790	**Flexural strength** (psi)	24,700	27,800	33,800	46,100
D790	**Flexural modulus** (10^5 psi)	5.3	9.7	15	18.9
D256	**Impact strength**, Izod (ft-lb/in of notch)	1.6	1.6	1.8	1.6
	THERMAL				
C177	**Thermal conductivity** (10^{-4} cal-cm/sec-cm^2-°C)	6.0	—	10.4	22.1
D696	**Coefficient of thermal expansion** (10^{-5} in/in-°C)				
	<150°C	4.7	2.4	2.2	1.5
	>150°C	10.8	—	—	—
D648	**Deflection temperature** (°F)				
	At 264 psi	320	545	600	600
UL 94	**Flammability rating**, 1/8 in	V-0	V-0	V-0	V-0
	ELECTRICAL				
D150	**Dielectric constant**				
	At 1 kHz	3.3	—	—	—
D150	**Dissipation factor**				
	At 1 kHz	0.003	—	—	—
D257	**Volume resistivity** (ohm-cm)				
	At 73°F, 50% RH	4.9×10^{16}	—	—	1.4×10^5



Ultra – high – molecular – weight – polyethylene

UHMWPE

TANNA Engineering Enterprises

Ultra-high-molecular-weight polyethylene (**UHMWPE**, **UHMW**) is a subset of the thermoplastic polyethylene. Also known as **high-modulus polyethylene**, (**HMPE**), or **high-performance polyethylene** (**HPPE**), it has extremely long chains, with a molecular mass usually between 2 and 6 million u. The longer chain serves to transfer load more effectively to the polymer backbone by strengthening intermolecular interactions. This result in a very tough material, with the highest impact strength of any thermoplastic presently made. UHMWPE is a linear, low-pressure, Ziegler-type-catalyst, polyethylene resin. Its weight-average molecular weight of 4 X 10^6 is approximately ten times that of high molecular weight, high-density polyethylene (HDPE) resins. UHMWPE has both he highest abrasion resistance and highest impact strength of any plastic. In fact, a 25mm (1") thick slap can stop a 0.38 caliber pistol slug at 150 mm (6"). Combined with abrasion resistance and toughness, the low coefficient of friction of UHMWPE yields a self-lubricating, non-stick surface. Static and dynamic coefficients are significantly lower than steel and most plastic materials.

Property	Test Method	Units	TIVAR - 1000
Physical			
Density	ASTM D-792	lbs/ft^3	58.01
Water Absorption	ASTM D-570	%	nil
Mechanical			
Yield Point	ASTM D-638	psi	3,050
Elongation at Yield	A STM D-638	%	15
Tensile Break	ASTM D-638	psi	5,800
Elongation at Break	ASTM D-638	%	250
Tensile Modulus	ASTM D-638	psi	120,000
Flexural Modulus	ASTM D-790	psi	110,000
Izod Impact	ASTM D-4020	ft-lbs/in^2	34
Tensile Impact	DIN 53448	ft-lbs/in^2	1,050
Sand Wheel Wear	ASTM G-65	AR-01 Steel=100	90
Hardness	ASTM D-2240	Shore D	68
Static Friction	ASTM D-1894		0.15
Dynamic Friction	ASTM D-1894		0.12
Compressive Modulus	ASTM D-695	psi	77,750
Compressive Deformation	ASTM D-621	% at 1000 psi	6-8
Thermal			
Coefficient of Thermal Exp.	ASTM D-696	in/in/°F	0.00011
Melt Point	ASTM D-3417	°F	278-289
Maximum Operating Temp.		°F	180
Electrical			
Volume Resistivity	ASTM D-257	ohm-cm	>10^{15}
Surface Resistivity	ASTM D-257	ohm	>10^{15}