

# PCTFE polychlorotrifluoroethylene

PARAMETER	UNIT	VALUE	REFERENCES
<b>GENERAL</b>			
Common name	-	polychlorotrifluoroethylene	
IUPAC name	-	poly(chlorotrifluoroethylene)	
ACS name	-	ethene, 1-chloro-1,2,2-trifluoro-, homopolymer	
Acronym	-	PCTFE	
CAS number	-	9002-83-9	
RTECS number	-	KM6555000	
Formula		$\left[ \begin{array}{cc} \text{F} & \text{F} \\   &   \\ -\text{C} & -\text{C}- \\   &   \\ \text{F} & \text{Cl} \end{array} \right]_n$	
<b>HISTORY</b>			
Date	-	1937, 1953 (commercialization)	
Details	-	first polymerization was reported by IG Farben	
<b>SYNTHESIS</b>			
Monomer(s) structure	-	$\text{F}_2\text{C}=\text{CFCl}$	
Monomer(s) CAS number(s)	-	79-38-9	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	116.469	
Monomer ratio	-	100%	
Formulation example	-	water, CTFE, potassium persulfate, sodium bisulfate, perfluorooctanoic acid	Ebnesajjad, S, Fluoroplastics. Vol. 1. Non-melt Processible Fluoroplastics, William Andrew, 2000.
Method of synthesis	-	emulsion polymerization is used in industry	Ebnesajjad, S, Fluoroplastics. Vol. 1. Non-melt Processible Fluoroplastics, William Andrew, 2000.
Temperature of polymerization	°C	21-53	
Pressure of polymerization	MPa	0.34-1	
Mass average molecular weight, $M_w$	dalton, g/mol, amu	250,000	
Molar volume at 298K	$\text{cm}^3 \text{mol}^{-1}$	53.2 (crystalline); 60.7 (amorphous)	
Van der Waals volume	$\text{cm}^3 \text{mol}^{-1}$	36.9 (crystalline); 36.9 (amorphous)	
<b>STRUCTURE</b>			
Crystallinity	%	29-33 (DSC)	
Cell type (lattice)	-	pseudohexagonal	
Cell dimensions	nm	a:c=0.644:4.15	
Chain conformation	-	helical	
<b>COMMERCIAL POLYMERS</b>			
Some manufacturers	-	Allied Signal	
Trade names	-	Aclar	

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<b>PHYSICAL PROPERTIES</b>			
Density at 20°C	g cm <sup>-3</sup>	2.1-2.14; 2.077 (amorphous); 2.187 (crystalline)	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
Color	-	clear	
Refractive index, 20°C	-	1.435	
Haze	%	<1	
Odor	-	odorless	
Melting temperature, DSC	°C	183-215	
Decomposition temperature	°C	260	
Thermal expansion coefficient, 23-80°C	°C <sup>-1</sup>	4.5E-5 to 7E-5	
Thermal conductivity, melt	W m <sup>-1</sup> K <sup>-1</sup>	0.26-0.27	Ebnesajjad, S, Fluoroplastics. Vol. 1. Non-melt Processible Fluoroplastics, William Andrew, 2000.
Glass transition temperature	°C	40-75	Ebnesajjad, S, Fluoroplastics. Vol. 1. Non-melt Processible Fluoroplastics, William Andrew, 2000.
Specific heat capacity	J K <sup>-1</sup> kg <sup>-1</sup>	900	
Heat of fusion	kJ kg <sup>-1</sup>	1.2	
Maximum service temperature	°C	-240 and 200	
Long term service temperature	°C	180	
Heat deflection temperature at 0.45 MPa	°C	126-129	
Heat deflection temperature at 1.8 MPa	°C	75	
Hansen solubility parameters, $\delta_D$ , $\delta_P$ , $\delta_H$	MPa <sup>0.5</sup>	15.6, 2.5, 4.7	
Interaction radius		5.8	
Hildebrand solubility parameter	MPa <sup>0.5</sup>	16.5	
Surface tension	mN m <sup>-1</sup>	30.9	Wu, S, Adhesion, 5, 39, 1973.
Dielectric constant at 100 Hz/1 MHz	-	2.7/2.2-2.6	
Dissipation factor at 100 Hz		0.01-0.06	
Dissipation factor at 1 MHz		0.023-0.027	
Volume resistivity	ohm-m	1E14	
Surface resistivity	ohm	1E15	
Electric strength K20/P50, d=0.60.8 mm	kV mm <sup>-1</sup>	157	
Permeability to nitrogen, 25°C	cm <sup>3</sup> cm cm <sup>-2</sup> s <sup>-1</sup> Pa <sup>-1</sup> x 10 <sup>12</sup>	0.000375	
Permeability to water vapor, 25°C	cm <sup>3</sup> cm cm <sup>-2</sup> s <sup>-1</sup> Pa <sup>-1</sup> x 10 <sup>12</sup>	0.0218	
Contact angle of water, 20°C	degree	90	Kwok, D Y; Neumann, A W, Colloids Surfaces A, 161, 49-62, 2000.
Surface free energy	mJ m <sup>-2</sup>	30.7	

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<b>MECHANICAL &amp; RHEOLOGICAL PROPERTIES</b>			
Tensile strength	MPa	28-78	
Tensile modulus	MPa	1300-1800	
Elongation	%	50-300	
Elastic modulus	MPa	900-1360	
Compressive strength	MPa	9-12	
Izod impact strength, unnotched, 23°C	J m <sup>-1</sup>	267	
Shore D hardness	-	75-90	
Rockwell hardness	R	75-112	
Shrinkage	%	2-15	
Water absorption, equilibrium in water at 23°C	%	0.00	
<b>CHEMICAL RESISTANCE</b>			
Acid dilute/concentrated	-	very good	
Alcohols	-	very good	
Alkalis	-	very good	
Aliphatic hydrocarbons	-	very good	
Aromatic hydrocarbons	-	very good	
Esters	-	very good	
Greases & oils	-	very good	
Halogenated hydrocarbons	-	poor	
Ketones	-	very good	
Good solvent	-	hot carbon tetrachloride, cyclohexane, mesitilene, toluene	
Non-solvent	-	common organic solvents at room temperature	
<b>FLAMMABILITY</b>			
Ignition temperature	°C	n/a	
Autoignition temperature	°C	n/a	
Limiting oxygen index	% O <sub>2</sub>	100	
Heat of combustion	J g <sup>-1</sup>	6,170	Hsieh, F-U; Stoltzfus, J M; Beeson, H D, Fire Mater., 20, 301-3, 1996.
Volatile products of combustion	-	HF, HCl, C <sub>1</sub> F=CF <sub>2</sub> , CO, CO <sub>2</sub>	
UL 94 rating	-	V-0	
<b>WEATHER STABILITY</b>			
Low earth orbit erosion yield	cm <sup>3</sup> atom <sup>-1</sup> x 10 <sup>-24</sup>	0.831	Waters, D L; Banks, B A; De Groh, K K; Miller, S K R; Thorson, S D, High Performance Polym., 20, 512-22, 2008.
<b>TOXICITY</b>			
NFPA: Health, Flammability, Reactivity rating	-	1/0/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
Oral rat, LD <sub>50</sub>	mg kg <sup>-1</sup>	>9,200	

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<b>BLENDS</b>			
Suitable polymers	-	PMMA	
<b>ANALYSIS</b>			
NMR (chemical shifts)	ppm	F NMR: CFCICF <sub>2</sub> Cl – 63.7; CF <sub>3</sub> CF <sub>2</sub> – 72.3 and more in ref	Hill, D J T; Thurecht, K J; Whittaker, A K, Radiat. Phys. Chem., 67, 729-36, 2003.