

ECTFE poly(ethylene-co-chlorotrifluoroethylene)

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	poly(ethylene-co-chlorotrifluoroethylene)	
IUPAC name	-	1-chloro-1,2,2-trifluoroethene; ethene	
CAS name	-	ethene, chlorotrifluoro-, polymer with ethene	
Acronym	-	ECTFE	
CAS number	-	25101-45-5; 9044-11-5	
HISTORY			
Person to discover	-	Hanford, W E of DuPont	Hanford, W E, US Patent 2,392,378, Du Pont, Jan. 8, 1946.
Date	-	1946 (patent), 1970 (commercialization)	
Details	-	reactor was charged with both monomers (40 parts of chlorotrifluoroethylene and 10 parts of ethylene) and copolymerized in the presence of benzoyl peroxide	
SYNTHESIS			
Monomer(s) structure	-	$\text{H}_2\text{C}=\text{CH}_2$ $\text{F}_2\text{C}=\text{CClF}$	
Monomer(s) CAS number(s)	-	74-85-1; 79-38-9	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	28.05; 116.469	
Monomer ratio	-	1	
Formulation example	-	water, monomers, solvent, initiator, chain transfer agent	
Temperature of polymerization	°C	0-5	
Time of polymerization	h	1.5	
Pressure of polymerization	MPa	1	
STRUCTURE			
Crystallinity	%	44-63	
Rapid crystallization temperature	°C	221-222	
COMMERCIAL POLYMERS			
Some manufacturers	-	Daaikin; Solvay	
Trade names	-	Neoflon; Halar	
PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	1.68-1.72	
Color	-	white	
Refractive index, 20°C	-	1.4470	
Odor	-	none	
Melting temperature, DSC	°C	188-242	
Decomposition temperature	°C	>350; 405 (1% weight loss)	
Crystallization point	°C	162-222	
Thermal expansion coefficient, 23-80°C	°C ⁻¹	0.8-1.7E-4	
Thermal conductivity, 40°C	W m ⁻¹ K ⁻¹	0.15-0.16	
Glass transition temperature	°C	63-85	

ECTFE poly(ethylene-co-chlorotrifluoroethylene)

PARAMETER	UNIT	VALUE	REFERENCES
Specific heat capacity	J K ⁻¹ kg ⁻¹	950-963 (23°C); 1,620 (melt)	
Heat of fusion	kJ kg ⁻¹	28-42	
Crystallization heat	kJ kg ⁻¹	5-40	
Maximum service temperature	°C	245-260	
Long term service temperature	°C	150-170	
Heat deflection temperature at 0.45 MPa	°C	62-116	
Heat deflection temperature at 1.8 MPa	°C	56-77	
Hansen solubility parameters, δ_D , δ_P , δ_H	MPa ^{0.5}	16.8, 8.4, 7.8	
Interaction radius		2.7	
Dielectric constant at 1000 Hz/1 MHz	-	2.47-2.6/2.50-2.59	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
Dissipation factor at 1000 Hz		0.0014-0.0017	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
Dissipation factor at 1 MHz		0.0013-0.009	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
Volume resistivity	ohm-m	5.5E13 to 1E14	
Surface resistivity	ohm	1E15	
Electric strength K20/P50	kV mm ⁻¹	14-110	
Arc resistance	s	135	
Coefficient of friction	-	0.1-0.3 (static); 0.1-0.3 (dynamic)	
Permeability to nitrogen, 25°C	cm ³ mm m ² s ⁻¹ atm 24 h	0.002	
Permeability to oxygen, 25°C	cm ³ mm m ² s ⁻¹ atm 24	0.001	
Permeability to water vapor, 25°C	cm ³ mm m ² s ⁻¹ atm 24	0.075	
Diffusion coefficient of water vapor	cm ² s ⁻¹ x10 ⁷	4.12 (20°C); 1.42 (90°C)	Hansen, C M, Prog. Org. Coat., 42, 167-78, 2001.
Contact angle of water, 20°C	degree	99 (adv) and 78 (rec)	Lee, S; Park, J-S; Lee, T R, Langmuir, 24, 4817-26, 2008.
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	31-57	
Tensile modulus	MPa	1,375-1,800	
Tensile stress at yield	MPa	22-32	
Elongation	%	200-325	
Tensile yield strain	%	3-9	
Flexural strength	MPa	40-55	
Flexural modulus	MPa	1,400-1,800	
Elastic modulus	MPa	1650	
Izod impact strength, notched, 23°C	J m ⁻¹	NB	

ECTFE poly(ethylene-co-chlorotrifluoroethylene)

PARAMETER	UNIT	VALUE	REFERENCES
Izod impact strength, notched, -40°C	J m ⁻¹	50-200	
Abrasion resistance (ASTM D1044)	mg/1000 cycles	5	
Shore D hardness	-	70-75	
Rockwell hardness	R	90-94	
Shrinkage	%	2.3-2.5	
Brittleness temperature (ASTM D746)	°C	-61 to <-76	
Melt index, 275°C/2.16 kg	g/10 min	1.5-60	
Water absorption, equilibrium in water at 23°C	%	<0.01 to <0.1	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	good	
Alcohols	-	good	
Alkalis	-	good	
Aliphatic hydrocarbons	-	good	
Aromatic hydrocarbons	-	good	
Esters	-	good	
Greases & oils	-	good	
Halogenated hydrocarbons	-	good	
Ketones	-	good	
Good solvent	-	insoluble at room temperature	
FLAMMABILITY			
Ignition temperature	°C	none	
Autoignition temperature	°C	655	
Limiting oxygen index	% O ₂	52-60	
Heat release	kW m ⁻²	74	
Volatile products of combustion	-	CDFA, TFA, DFA	
UL 94 rating	-	V-0	
WEATHER STABILITY			
Low earth orbit erosion yield	cm ³ atom ⁻¹ x 10 ⁻²⁴	1.79	Waters, D L; Banks, B A; De Groh, K K; Miller, S K R; Thorson, S D, High Performance Polym., 20, 512-22, 2008.
TOXICITY			
HMIS: Health, Flammability, Reactivity rating	-	1/0/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
TLV, ACGIH	mg m ⁻³	5 (respirable); 10 (total)	
OSHA	mg m ⁻³	5 (respirable); 15 (total)	

ECTFE poly(ethylene-co-chlorotrifluoroethylene)

PARAMETER	UNIT	VALUE	REFERENCES
PROCESSING			
Typical processing methods	-	compression molding, electrostatic powder coating, fluidized bed coating, film/tube extrusion, flame and plasma spraying, injection molding monofilament extrusion, wire & cable injection molding	
Processing temperature	°C	250-280	
Applications	-	cable insulation, capacitors, coatings (agitators, centrifuges, electroplating equipment, exhaust hoods, filters, piping systems, reactors, semiconductor storage tanks, vessels), films, fibers, hollow fiber membranes, pipes, printed circuits, rods, sheet, solar collectors	
Outstanding properties	-	chemical and thermal resistance, purity, surface characteristics	