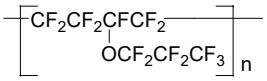
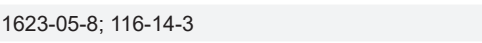
PFA perfluoroalkoxy resin

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	perfluoroalkoxy resin; poly[tetrafluoroethylene-co-perfluoro(alkyl vinyl ether)]	
CAS name	-	propane, 1,1,1,2,2,3,3-heptafluoro-3-[(1,2,2-trifluoroethenyl) oxy]-, polymer with 1,1,2,2-tetrafluoroethene	
Acronym	-	PFA	
CAS number	-	26655-00-5	
Formula			
HISTORY			
Person to discover	-	Carlson, D P	
Date	-	1970; 1973 (commercialization)	
Details	-	copolymerization in halogenated solvents	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
SYNTHESIS			
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	1623-05-8; 116-14-3	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	266.04; 100.02	
Monomer(s) expected purity(ies)	%	98	
Formulation example	-	monomers, water, water-soluble initiator, surfactant	
Method of synthesis	-	aqueous polymerization	
Temperature of polymerization	°C	70-95	
Time of polymerization	h	3-6	
Pressure of polymerization	MPa	1.7-2.4	
Drying temperature	°C	125-150	
STRUCTURE			
Crystallinity	%	45-70	
Chain conformation	-	13/6 helix	
COMMERCIAL POLYMERS			
Some manufacturers	-	3M; Daikin; Solvay	
Trade names	-	Dyneon; Neoflon; Hyflon	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	2.12-2.18	
Bulk density at 20°C	g cm^{-3}	0.25-0.6	
Color	-	translucent to white	
Refractive index, 20°C	-	1.34-1.35	
Transmittance	%	71-91 (UV); 91-96 (vis); 96-98 (IR)	Ebnesajjad, S, Fluoroplastics. Vol. 2. Melt Processible Fluoroplastics, William Andrew, 2003.
Haze	%	4	

PFA perfluoroalkoxy resin

PARAMETER	UNIT	VALUE	REFERENCES
Odor	-	odorless	
Melting temperature, DSC	°C	285-315	
Decomposition temperature	°C	270; 400	
Thermal expansion coefficient, 23-80°C	$^oC^{-1}$	1.2-2.1E-4	
Thermal conductivity, melt	W m^{-1} K^{-1}	0.19-0.195	
Glass transition temperature	°C	2-15	
Specific heat capacity	J K^{-1} kg^{-1}	1,172	
Heat of fusion	J g^{-1}	17.1	Zhong, X; Yu, L; Zhao, W; Zhang, Y; Sun, J, Polym. Deg. Stab., 40, 115-16, 1993.
Maximum service temperature	°C	-240 to 260	
Long term service temperature	°C	250-260	
Heat deflection temperature at 0.45 MPa	°C	72	
Heat deflection temperature at 1.8 MPa	°C	49; 85 (20% glass fiber)	
Surface tension	mN m^{-1}	22.0	Becker, K, Int. Biodet. Biodeg., 41, 93-100, 1998.
Dielectric constant at 100 Hz/1 MHz	-	2.04/2.04	
Dissipation factor at 100 Hz	E-4	2	
Dissipation factor at 1 MHz	E-4	7	
Volume resistivity	ohm-m	1E15 to 1E16	
Surface resistivity	ohm	1E15	
Electric strength K20/P50, d=0.60.8 mm	kV mm^{-1}	260	
Coefficient of friction	-	0.1-0.3 (kinetic, PFA/steel); 0.13-0.16 (20% glass fiber)	
Permeability to nitrogen, 25°C	cm^3 m^{-2} 24 h^{-1} atm^{-1}	2,000	
Permeability to oxygen, 25°C	cm^3 m^{-2} 24 h^{-1} atm^{-1}	6,700	
Permeability to water vapor, 25°C	g m^{-2} day^{-1}	2	
Diffusion coefficient of water vapor	cm^2 s^{-1} $x10^7$	4.05 (20°C); 8.5 (90°C)	Hansen, C M, Prog. Org. Coat., 42, 167-78, 2001.
Contact angle of water, 20°C	degree	122	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	20-31.7; 34 (20% glass fiber)	
Tensile modulus	MPa	276	
Tensile stress at yield	MPa	12-15	
Elongation	%	150-360; 6 (20% glass fiber)	
Flexural modulus	MPa	550-740; 1,145 (20% glass fiber)	
Elastic modulus	MPa	480	
Shore D hardness	-	55-65	
Shrinkage	%	1 (150°C)	

PFA perfluoroalkoxy resin

PARAMETER	UNIT	VALUE	REFERENCES
Water absorption, equilibrium in water at 23°C	%	<0.02 to <0.03	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	resistant	
Alcohols	-	resistant	
Alkalis	-	resistant	
Aliphatic hydrocarbons	-	resistant	
Aromatic hydrocarbons	-	resistant	
Esters	-	resistant	
Greases & oils	-	resistant	
Halogenated hydrocarbons	-	resistant	
Ketones	-	resistant	
Other	-	reacts with fluorine and molten alkalis	
FLAMMABILITY			
Ignition temperature	°C	530-550	
Autoignition temperature	°C	530-560	
Limiting oxygen index	% O_2	>95	
Heat of combustion	J g^{-1}	6,110	
Volatile products of combustion	-	CO, CO_2, HF, smoke	
UL rating	-	V-0	
TOXICITY			
HMIS: Health, Flammability, Reactivity rating	-	2/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
OSHA	mg m^{-3}	5 (respirable), 15 (total)	
Oral rat, LD_{50}	mg kg^{-1}	>11,000	
ENVIRONMENTAL IMPACT			
Aquatic toxicity, *Daphnia magna*, LC_{50}, 48 h	mg l^{-1}	>10,000	
Aquatic toxicity, *Fathead minnow*, LC_{50}, 48 h	mg l^{-1}	>10,000	
PROCESSING			
Typical processing methods	-	coating, extrusion, injection molding	
Additives used in final products	-	Fillers: calcium hydroxide, carbon black, graphite, magnesium oxide, metal particles, molybdenum disulfide, PTFE	
Applications	-	automotive weather seals for doors and windows, coating for hostile environments, column packing, filtration, fittings, marine coatings, pipes, pump, silicon wafer carriers, tubing, wear resistant products	
Outstanding properties	-	weather resistance, thermal resistance, chemical resistance	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	COF – 1884; C=O – 1813, 1775; $CONH_2$ – 1768, 1587	Pianca, M; Barchiesi, E; Esposto, G; Radice, S, J. Fluorine Chem., 95, 71-84, 1999.