PFI perfluorinated ionomer

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	perfluorinated ionomer	
CAS name	-	2-[1-difluoro[(trifluoroethenyl)oxy]methy]-1,2,2,-tetrafluoroethoxy]-1,1,2,2-tetrafluoro-ethanesulfonic acid, polymer with tetrafluoroethylene	
Acronym	-	PFI	
CAS number	-	31175-20-9; 66796-30-3	
HISTORY			
Person to discover	-	Walther Grot	
Date	-	1968	
Details	-	PTFE modification	
SYNTHESIS			
Monomer(s) structure	-	CF_2=CF_2; perfluorosulfonic acid	
Mass average molecular weight, M_w	dalton, g/mol, amu	100,000-1,000,000	Heitner-Wirguin, C, J. Membrane Sci., 120, 1-33, 1996.
STRUCTURE			
Crystallinity	%	14-23 (nonionic and carboxylated forms); 3-12 (sulfonated form); with increase of equivalent weight from 1100 to 1500, the degree of crystallinity increases from 12 to 22%	Mauritz, K A; Moore, R B, Chem. Rev., 104, 4535-85, 2004.
Crystallite size	nm	3.9-4.4	Mauritz, K A; Moore, R B, Chem. Rev., 104, 4535-85, 2004.
Spacing between crystallites	nm	1-3.3	Mauritz, K A; Moore, R B, Chem. Rev., 104, 4535-85, 2004.
Chain conformation	-	zigzag (34 carbon atoms)	Mauritz, K A; Moore, R B, Chem. Rev., 104, 4535-85, 2004.
COMMERCIAL POLYMERS			
Some manufacturers	-	DuPont; Solvay	
Trade names	-	Nafion; Hyflon	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.97-1.98	
Color	-	white	
Odor	-	odorless	
Decomposition temperature	°C	280	
Glass transition temperature	°C	110-165	Ghielmi, A; Vaccarono, P; Troglia, C; Arcella, V, J. Power Sources, 145, 1008-15, 2005.
Available acid capacity	meq/g	0.9-0.92	
Maximum service temperature	°C	240	
Long term service temperature	°C	175	
Conductivity	S cm^{-1}	0.1	
Diffusion coefficient of water vapor	cm^2 s^{-1} x10^7	1-7.5	Hallinan, D T; De Angelis, M G; Baschetti, M C; Sarti, G S; Elabd, Y A, Macromolecules, 43, 4667-78, 2010.

PFI perfluorinated ionomer

PARAMETER	UNIT	VALUE	REFERENCES
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	23-43	
Tensile modulus	MPa	64-249 (depends on moisture content and temperature)	
Tensile stress at yield	MPa	14-18	
Elongation	%	250-350	
Young's modulus	MPa	250-340	
Tear strength	g mm^{-1}	3,000-6,000	
Water absorption, equilibrium in water at 23°C	%	38	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	very good	
Alcohols	-	poor	
Alkalis	-	very good	
Aliphatic hydrocarbons	-	very good	
Aromatic hydrocarbons	-	very good	
Esters	-	very good	
Greases & oils	-	very good	
Halogenated hydrocarbons	-	very good	
Ketones	-	very good	
Other	-	only sodium attacks PFI	
FLAMMABILITY			
Limiting oxygen index	% O_2	95	
Heat of combustion	J g^{-1}	5,800	
Volatile products of combustion	-	CO, CO_2, HF, SO_2, COF_2, COS	
UL 94 rating	-	V-0	
WEATHER STABILITY			
Products of degradation	-	oxygen radicals in side chain and perfluorinated radicals obtained by photo-Fenton reactions	Bosnjakovic, A; Kadirov, M K; Schlick, S, Res. Chem. Intermed., 33, 8-9, 677-87, 2007.
TOXICITY			
HMIS: Health, Flammability, Reactivity rating	-	1/1/1	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
Oral rat, LD_{50}	mg kg^{-1}	20,000	
PROCESSING			
Applications	-	fuel cells, ion-exchange membranes, moisture regulator, proton-exchange membranes, super-acid catalyst	
Outstanding properties	-	chemical resistance, ion conductive, thermal stability	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	SO_3 – 1056; C-O-C – 969 (main chain), 982 (side chain), and more	Danilczuk, M; Lin, L; Schlick, S; Hamrock, S J; Schaberg, M S, J. Power Sources, in press, 2011.

PFI perfluorinated ionomer

PARAMETER	UNIT	VALUE	REFERENCES
NMR (chemical shifts)	ppm	H NMR: hydrogen ions – 5.5-9; water physically sorbed – 3.5	Nosaka, A Y; Nosaka, Y, J. Power Sources, 180, 733-37, 2008.