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Fluoropolymer properties and applications in pulp and paper mills

Scope

Fluoropolymers have unique properties among thermoplastics, including outstanding chemical resistance to higher temperatures than other plastics; non-stick, non-wetting and low-friction surfaces; relatively low liquid and gas permeability; excellent UV resistance, and are non-burning materials available in a wide variety of product forms. High cost generally limits their use to specialized, high value applications, often competing with costly corrosion resistant alloys. This document both helps users in a pulp and paper mill to identify the correct fluoropolymer for a particular application and, by educating the reader, encourages wider appreciation and use of fluoropolymers in challenging corrosion, sealing and wear applications. *Fluoroelastomers are not discussed in this document.*

Commercial fluoropolymers

Commercial fluoropolymers for corrosion protection applications come in two groups: fully fluorinated polymers and partially fluorinated polymers. Fully fluorinated polymers, also called perfluoropolymers, include PTFE, FEP, PFA and MFA. Partially fluorinated polymers include PVDF, ETFE, and ECTFE. Table 1 lists trade names of different types of fluoropolymers available for pulp and paper mill applications.

Table 1. Trade names and manufacturers of commercial fluoropolymers

Fluoropolymer	Trade names [manuf.]
Fluorinated ethylene-propylene (FEP)	Teflon [DuP]; Neoflon [Dai]; Dyneon [3M]
Perfluoroalkoxy (PFA) Perfluoromethylvinylether (MFA)	Teflon [DuP]; Hyflon [Sol]; Fluon [Asa]; Neoflon [Dai]; Dyneon [3M] MFA - Hyflon [Sol]
Polytetrafluorethylene (PTFE)	Teflon [DuP]; Algoflon, Polymist [Sol]; Polyflon [Dai]; Fluon [Asa]
Polyvinylidene fluoride (PVDF)	Kynar[Ark]; Hylar, Solef [Sol]; Dyneon [3M]
Ethylene chlorotrifluoroethylene (ECTFE)	Halar [Sol]
Ethylene tetrafluoroethylene (ETFE)	Tefzel [DuP], Fluon [Asa]; Neoflon [Dai]; Dyneon [3M]

Manuf.: DuP – E.I. DuPont; Sol - Solvay-Solexis; Ark - Arkema Inc.; Asa - Asahi Glass; Dai – Daikin Industries

All known manufacturers have been listed; if your company supplies these materials, please notify TAPPI to be included.

Users of this TIP should consult the manufacturer for the latest product information.

Safety precautions

There are no special safety precautions associated with this TIP.

Their wide-ranging chemical resistance generally makes all fully fluorinated and most partially fluorinated fluoropolymers “chemically inert” in all pulp and paper environments: a notable exception is PVDF’s susceptibility to attack in hot alkaline solutions.

Fully fluorinated resins generally resist a wider range of chemicals to higher temperatures than partially fluorinated polymers. However, partially fluorinated resins generally have superior mechanical properties, giving them an advantage in free-standing structures, including piping systems. Compared to fully fluorinated types, partially fluorinated resins are stiffer, tougher, harder, and have higher abrasion resistance at their service temperature limits. Table 2 lists property data for seven fluoropolymers of greatest practical interest.

Table 2. Physical and mechanical properties of commercial fluoropolymers

Property	Units	PVDF	ECTFE	ETFE	FEP	MFA	PFA	PTFE
Melting Point	°C	160-172	222-242	255-280	260-275	265-290	280-315	317-337
Specific Gravity	g/cm ³	1.75 –1.78	1.68-1.71	1.70-1.74	2.10-2.20	2.1 -2.15	2.12-2.17	2.12-2.16
Tensile Strength	MPa	31-57	45-57	40-52	21-30	28-30	21-31	20-40
Tensile Modulus	MPa*10 ³	1.4-2.4	1.4-2.1	0.9-1.3	0.35-0.5	0.4-0.5	0.5-0.6	0.35-0.75
Hardness	Shore D	75-78	70-75	63-72	60	55-60	55-60	50-65
Brittleness Temp.	°C	-10 to +10	-76	< -105	< -70	-190	-190	-200
Therm Exp. Coeff.	*10 ⁻⁵ /°C	12-14	9	8-12	9-11	12-20	19-25	21-25
Max. contin. use T.	°C	150	175	155	205	225	260	260
Chem. resistance		Good	Very good		Excellent			

An important physical mechanism that influences the performance of any polymer in chemical service, especially in lined pipe and equipment, is permeation of fluid molecules through the polymer. All polymers, including thermoplastics and thermoset materials like FRP composites and epoxy paints, have finite fluid permeation. Permeation can contribute to lining or coating failure by blistering if gas or liquid builds up within or behind the polymer layer. Permeation of corrosive chemicals can corrode the substrate protected by a polymer lining.

PVDF and ECTFE are significantly less permeable than PTFE. Table 3 shows the variation with temperature of chlorine gas permeability of two partially fluorinated (Halar) and three fully fluorinated fluoropolymers.

Table 3. Chlorine permeability: ml-mil/(24 hrs, 100 in.² atm)

	25°C	70°C	90°C
Halar 901	41	202	1062
Halar 902	296	595	1095
ETFE	746	1331	2509
FEP	391	1496	2560
MFA	901	2243	4035

Specifying the correct fluoropolymer for a particular application requires matching the critical properties of the fluoropolymer with those required for the application, as long as the material is available in the required product forms; e.g., if chemical resistance is acceptable, permeation at the service temperature may be the critical property for selecting a particular fluoropolymer.