

표 1. Properties of Hydrogen, Fluoride and Chloride

Properties	H	F	Cl
Atomic Number	1	9	17
Atomic Mass	1.0079	18.998	35.4527
Melting Point (°C)	-259.14	-219.62	-101
Boiling Point (°C)	-252.87	-188.14	-34.6
Date of Discovery	1766	1886	1774
Color	colorless	greenish	green
Density (g/mL)	0.090	1.696	3.17
Outer-Shell Electron Configuration	1s ¹	2s ² 2p ⁵	3s ² 3p ⁵
Atomic Radius (Å)	0.79	0.57	0.97
Bonding Radius (Å)	0.32	0.72	0.99
Electron Negativity	2.2	3.98	3.16
CH ₃ -X Bond Energy (kcal/mol)	104	108	84
C-X Bond Length (Å)	1.901	1.317	1.766
C-X Polarity	0.66	0.68	2.58

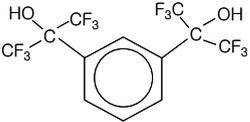
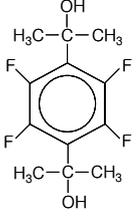
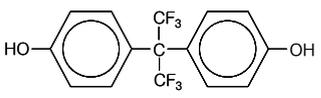
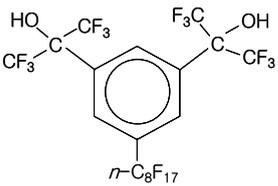
표 2. Commercialization Timeline of Major Fluoropolymers vs Key Processing/Application Trade-offs

Fluoropolymers	Year Commercialization	Monomers	Trade-off +	Trade-off -
PTFE	1947	TFE	Continuous Use Temperature 260°C	Non-melt Processible
PCTFE	1953	CTFE	Melt Processible/Non-Melt Processible	Maximum Continuous Use Temperature 180°C
FEP	1960	TFE,HFP ³	Melt-Processible	Maximum Continuous Use Temperature 200°C
PVF	1961	VF ¹	Thin film/Weatherable	Maximum Continuous Use Temperature 107°C
PVDF	1961	VDF ²	Melt-processible	Maximum Continuous Use Temperature 150°C
ECTFE	1970	CTFE,E ⁴	Hardness/Toughness	Maximum Continuous Use Temperature 150°C
PFA	1972	TFE,PAVE ⁵	Melt processible. Continuous Use Temperature 260°C	Low Molecular Weight
ETFE	1973	TFE,E	Hardness/Toughness	Maximum Continuous Use Temperature 150°C
Teflon [®] AF	1985	TFE,PDD ⁶	Soluble in Special Halogenated Solvent	High Cost

표 3. Coefficient of Friction and Surface Energy of Unfilled Fluoropolymers

Fluoropolymers	Formula	Coefficient of Friction (Dynamic)	Critical Surface Tension (dyne/cm)	Surface Tension (Harmonic-Mean Method) dyne/cm
Polyethylene	-CH ₂ -CH ₂ -	0.33	31	36.1
Polyvinylfluoride	-CHF-CH ₂ -	0.3	28	38.4
Polyvinylidene fluoride	-CF ₂ -CH ₂ -	0.3	25	33.2
Polytrifluoroethylene	-CF ₂ -CHF-	0.3	22	-
Polytetrafluoroethylene	-CF ₂ -CF ₂ -	0.04	18	22.5
Polyvinylchloride	-CHCl-CH ₂ -	0.5	39	41.9
Polyvinylidenechloride	-CCl ₂ -CH ₂ -	0.9	40	45.4

표 4. Fluorinated Diol Used to Prepare Polyurethane Resins

Diol	Application
$\text{HOCH}_2(\text{CF}_2)_2\text{CH}_2\text{OH}$	Segment polyether polyurethanes
$\text{HOCH}_2(\text{CF}_2)_3\text{CH}_2\text{OH}$	Elastomers
$\text{HO}(\text{CH}_2)_2(\text{CF}_2)_2\text{OH}$	Segment polyether polyurethanes
$\text{HO}(\text{CF}_2)_2\text{O}(\text{CF}_2)_4\text{O}(\text{CF}_2)_2\text{OH}$	Cladding for optical fiber
$\text{H}(\text{CF}_2)_4\text{CH}_2\text{OCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$	Colored resin powders
$\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$	Antithrombogenic elastomers
$\text{C}_6\text{F}_{13}\text{SO}_2\text{N}(\text{CH}_3)\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$	Photocurable polyurethane acrylate coatings
$\text{C}_6\text{F}_{13}\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$	Photocurable polyurethane acrylic resins
$\text{HOCH}_2\text{CH}_2\text{C}(\text{CF}_3)\text{FCF}_2(\text{CF}_2\text{CF}_2)_n\text{CH}_2\text{CH}_2\text{OH}$	[$n = 2$] Coating Transparent elastomer [$n = 0-7$] Coatings
	Electrical insulation Marine coatings
	Polyurethane resins
$\text{C}_8\text{F}_{17}\text{SO}_2\text{N}(\text{CH}_2\text{CH}_2\text{OH})_2$	Nonthrombogenic medical implants
	Coatings Lubricants for recording media Printed circuit board Thermal printer compound Elastomers
$(\text{CF}_2)_4[\text{OCF}_2\text{CF}_2\text{SO}_2\text{N}(\text{CH}_2\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}]_2$	Toluene diisocyanate polymer
	Modified epoxy resins
$\text{HO}(\text{CH}_2\text{CH}_2\text{CH}_2\text{O})_6 \cdot \text{I}(\text{CH}_2\text{CHO})_4 \cdot \text{O}(\text{CH}_2\text{CH}_2\text{O})_0 \cdot \text{9H}$ $\text{CF}_3(\text{CF}_2)_4 \cdot \text{5CH}_2$	Poly(fluoroalkylether)urethanes

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