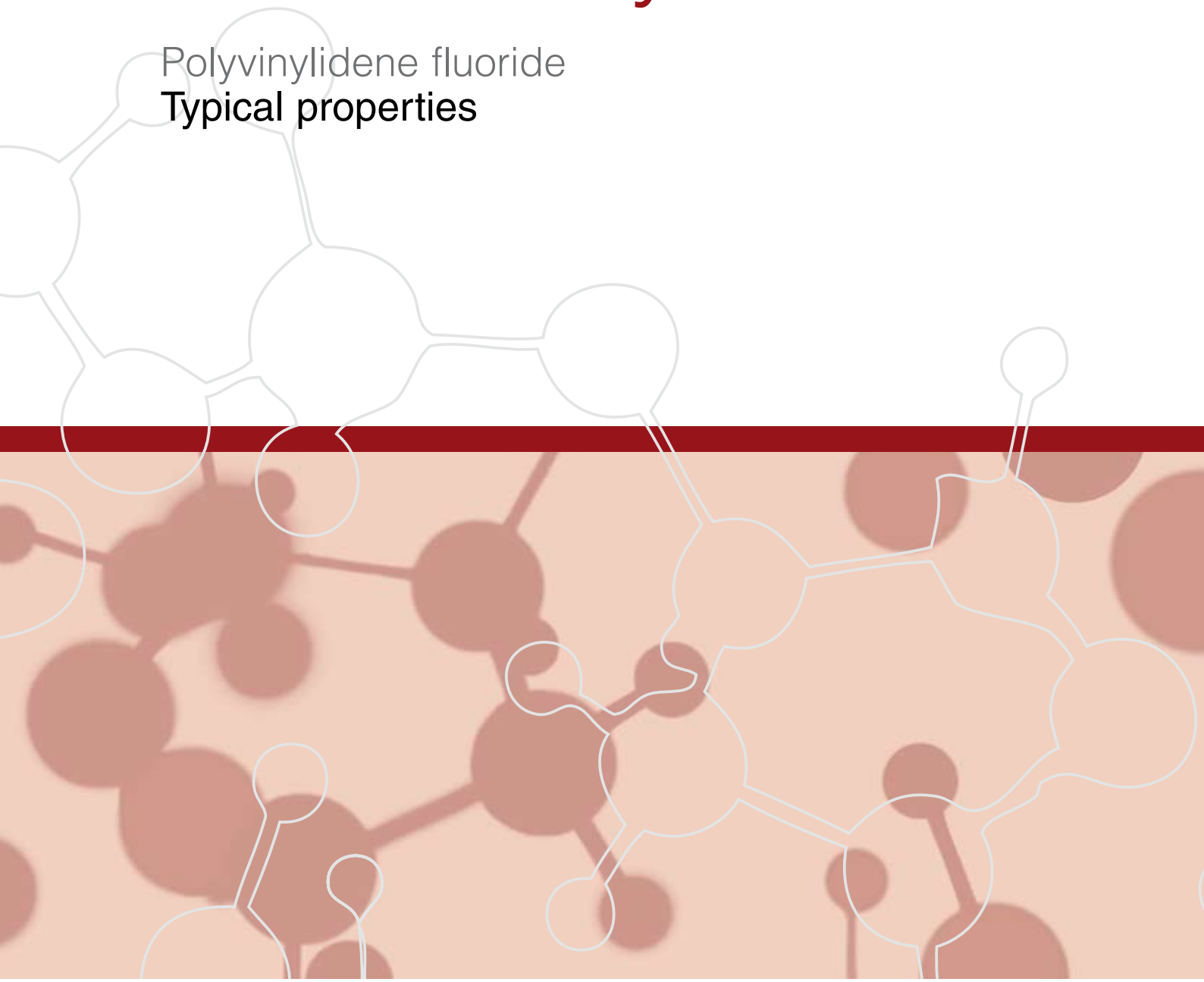
Solef® & Hylar® PVDF

Polyvinylidene fluoride

Typical properties



Solvay
Solexis

SOLVAY

Solef® and Hylar® PVDF
A remarkable combination of properties

PVDF is a fluorinated semi-crystalline thermoplastic which is obtained by polymerizing vinylidene fluoride. This fluorinated polymer has been manufactured and marketed for more than 30 years, using both suspension process (Solef®) and emulsion process (Hylar®) developed and perfected by Solvay Solexis. PVDF, without any additives, has the intrinsic stability inherent to fluoropolymers, even when exposed to harsh environments. It provides the user with a unique combination of properties leading to longer equipment life. The most important properties of PVDF are listed below:

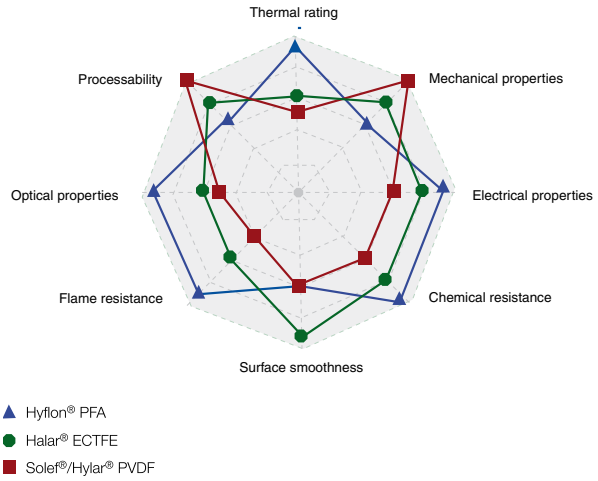
- Excellent chemical resistance to most aggressive substances and solvents,
- Excellent mechanical strength and toughness,
- High abrasion resistance,
- High temperature capabilities: continuous use service temperature up to 150°C (302°F),
- Excellent ageing resistance,
- High purity,
- Resistance to UV and nuclear radiations,
- Excellent intrinsic fire resistance,
- Low permeability to most gases and liquids,
- Easily melt-processed by standard methods of extrusion and molding,
- Wide range of rigid and flexible grades available.

Besides the PVDF homopolymers, Solvay Solexis offers a wide products range of VF2-HFP copolymers, and VF2-CTFE copolymers which stand out for their better cold temperature behaviour. The VF2-CTFE range comprises the Solef 60000 series, which offers an improved balance between good cold temperature properties and thermomechanical properties of the homopolymers.
PVDF is extensively used in the general chemical processing industry, the high purity semiconductor market, and the wire and cable industry.
Solvay Solexis today offers a growing choice of PVDF grades which are associated with new applications such as the Oil and Gas industry, Automotive, Building industry, Electronics, Chimney linings, Lithium Batteries, Fuel cells, Food and Pharmaceutical industries.

In addition to the Solef® and Hylar® PVDF resins, Solvay Solexis offers a wide range of other fluoropolymers also easily processed by injection, extrusion, and all conventional processing techniques:

- Halar® ECTFE (copolymer of ethylene and chlorotrifluoroethylene),
- Hyflon® PFA (copolymer of tetrafluoroethylene and perfluoroalkylvinylethers).

Relative performance of Solvay Solexis melt processable fluoropolymers



Assistance in the selection of the most suitable resin and processing conditions is available through Solvay Solexis' commercial and technical teams.

Solef® and Hylar® PVDF - Typical properties

GRADE						
Major applications			Solef® 1000 series			
			1008	1009	1010	1012
			Low viscosity all purposes injection	Mean viscosity all purposes injection/extrusion	Medium viscosity all purposes extrusion	High viscosity extrusion
P = power. G = granules			P & G			
Physical properties	**Standards**	**Units**				
Density (23°C/ 73.4°F)	ASTM D 792	g/cm³	1.78			
Water absorption (24h at 23°C / 73.4°F)	ASTM D 570	%	< 0.04			
Melt flow index (230°C/446°F)	ASTM D 1238					
	10kg	g/10 min	-	-	-	5
	5kg	g/10 min	24	10	6	1.5
	2.16kg	g/10 min	8	3.5	2	0.5
Mechanical properties						
Tensile (23°C/ 73.4°F)	ASTM D 638 (1)					
Tensile stress at yield	50mm/min	MPa (psi)	53-57 (7685-8265)			
Tensile stress at break	50mm/min	MPa (psi)	35-50 (5075-7250)			
Elongation at yield	50mm/min	%	5-10			
Elongation at break	50mm/min	%	20-50			
Modulus	1mm/min	MPa (psi)	2000-2400 (290000-348000)			
Flexion (23°C/ 73.4°F)	ASTM D 790 (2)					
Maximum load	50mm/min	MPa (psi)	78 (11310)	77 (11165)	77 (11165)	75 (10875)
Modulus	2mm/min	MPa (psi)	2000-2200 (290000-319000)			
IZOD impact (notched V 10mm - 23°C/ 73.4°F - 4mm thick)	ASTM D 256	J/ m (ft·lbf/ in)	55 (1.02)	65 (1.22)	110 (2.06)	150 (2.81)
Shore D hardness (2mm thick)	ASTM D 2240	-	78			
Abrasion resistance	TABER CS 17/ 1kg	mg/ 1000 rev	5-10			
Friction coefficient: static	ASTM D 1894	-	0.2-0.4			
dynamic		-	0.2-0.3			
Thermal properties						
Crystallinity by DSC	ASTM D 3418					
Melting point		°C (°F)	172 (342)			
Heat of fusion (80°C/ 176°F to end of melting)		J/ g (Btu/ lb)	64 (28)	64 (28)	63 (27)	60 (26)
Crystallizing point		°C (°F)	140/ 284			
Crystallization heat		J/ g (Btu/ lb)	58 (25)	58 (25)	57 (24)	56 (24)
VICAT point (4mm thick - load 1kg)	ISO 306	°C (°F)	171 (340)	171 (340)		170 (338)
Deflection temperature (4mm thick)	ASTM D 648					
Load 0.46 MPa (66.7 psi)	After annealing	°C (°F)	148 (298)	147 (297)	147 (297)	145 (293)
Load 1.82 MPa (264 psi)	After annealing	°C (°F)	115 (239)	113 (235)	113 (235)	112 (234)
Glass transition (Tg)	DMTA	°C (°F)	-30 (-22)			
Brittleness temperature (on 2mm pressed sheet)	ASTM D 746 A	°C (°F)	0-10 (32-50)			
Molding shrinkage		%	2-3			
Thermal stability	TGA. T° for 1% w loss in air	°C (°F)	375-400 (707-752)			
Linear thermal expansion coefficient	ASTM D 696	10^{-6}/ K (10^{-6}/ °F)	120-140 (67-78)			
Thermal conductivity at 23°C (73.4°F)	ISO 8894-2	W/ m.K (Btu·in/ h·ft².°F)	0.2 (1.4)			
Specific heat	23°C & 100°C (73.4°F & 212°F)	J/ g.K (Btu/ lb·°F)	1.2-1.6 (0.28-0.38)			
Electrical properties						
Surface resistivity Voltage<1V, after 2min - 500V at 23°C (73.4°F)	ASTM D 257 DIN 53483	ohm/ square	≥ 1.10^{14}			
Volume resistivity Intensity = 10mA, after 2min at 23°C (73.4°F)	ASTM D 257 DIN 53483	ohm.cm	≥ 1.10^{14}			
Fire resistance						
UL-94 Flammability test	UL-94	Class	V-0	-	V-0	
Limiting oxygen index (sheet 3mm thick)	ASTM D 2863	%	44			

(1) Tensile tests performed on extruded sheets (except for Solef 1015: compression molded specimen)
(2) Flexural tests performed on compression molded sheets
(3) Partial break
(4) NS: no significant

(5) Optional products available with a > 90% LOI (code: XXXXX/0009)
(6) Results achieved with formulated grade (code: XXXX/0000)
(7) MFI under 21,6kg/ 230°C

PVDF HOMOPOLYMERS					VF2 - HFP COPOLYMERS				
	Solef® 6000 series			Hylar®	Solef®				
1015	6008	6010	6012	460	11008	11010	21216	21508	
Very high viscosity membranes solution	Low viscosity injection	Medium viscosity all purposes extrusion	High viscosity Compression molding	Broad MWD Chain branched extrusion	Low viscosity Wire & Cable extrusion	Medium viscosity Wire & Cable extrusion	Lithium batteries solution	High elongation extrusion	Very Air-
P	P & G			P & G	P & G		P	P & G	
		1.78		1.76	1.78				
		< 0.04		< 0.04	< 0.04				
0.7	-	-	5	2.6	-	-	1.3[7]	-	
0.2	24	6	1.5	0.6	24	6	-	24	
-	8	2	0.5	-	8	2	-	8	
		53-57 (7685-8265)		48 (7000)	20-35 (2900-5075)		15-25 (2175-3625)	15-18 (2175-2610)	
		35-50 (5075-7250)		41 (6000)	20-40 (2900-5800)		25-45 (3625-6525)	20-40 (2900-5800)	
		5-10		10	10-12		15-18	12-15	
		20-50		100	200-600		300-650	600-750	
		2000-2400 (290000-348000)		1300 (188500)	1100 (159500)	1050 (152250)	500 (72500)	420 (60900)	
70 (10150)	78 (11310)	77 (11165)	75 (10875)	55 (8000)	40 (5800)	37 (5365)		-	
		2000-2200 (290000-319000)		1500 (217500)	1000 (145000)	900 (130500)	400 (58000)	400 (58000)	
385 (7.20)[3]	65 (1.22)	120 (2.24)	160 (3.00)	161 (3.01)	125 (2.34)	170 (3.18)	-	180 (3.37)	
		77		78	72	72	-	60	
		5-10		5-10	5-15				
		0.2-0.4		0.2-0.4	0.2-0.4				
		0.2-0.3		0.2-0.3	0.2-0.3				
171 (340)	172 (342)	172 (342)	171 (340)	160 (320)	160 (320	160 (320)	135 (275)	135 (275)	
59 (25)	62 (27)	60 (26)	59 (25)	46 (20)	39 (16.8)	38 (16.3)	26 (11.2)	23 (9.9)	
	139 (282)	138 (280)	138 (280)	132 (270)	121 (250)	122 (252)	98 (208)	92 (198)	
53 (23)	58 (25)	56 (24)	54 (23)	46 (20)	37 (15.9)	35 (15.0)	28 (12.0)	24 (10.3)	
		170 (338)		154 (309)	150 (302)	150 (302)	131 (268)	120 (248)	
143 (289)	147 (294)	145 (293)	143 (289)	127 (260)	100 (212)	100 (212)	-	62 (144)	
110 (230)	112 (234)	110 (230)	108 (226)	88 (190)	52 (126)	52 (126)	39 (102)	40 (104)	
		-32 (-26)		-39 (-38)	-29 (-20)	-29 (-20)	-30 (-22)	-29 (-20)	
-10 to 0 (14-32)	0-10 (32-50)	-5 to+5 (23-41)	-10 to 0 (14-32)	-	-17 (1.4)	-18 (0)	-35 (-31)	-22 (-8)	
		2-3		2-3	2-3	2-3	-	2-3	
	375-400 (707-752)	>400 (>752)[6]	>400 (>752)[6]	375-400 (707-752)	330-370 (626-698)	330-350 (626-662)	330-350 (626-662)	340-375 (644-707)	340-
		120-140 (67-78)		120-130 (67-72)	140-160 (78-89)		160-180 (89-100)	150-180 (83-100)	210
		0.2 (1.4)		0.2 (1.4)	0.19 (1.3)		0.18 (1.2)	0.18 (1.2)	
		1.2-1.6 (0.28-0.38)		1.3 (0.31)	1.2-1.6 (0.28-0.38)				
		≥ 1.10^{14}		≥ 1.10^{14}	≥ 1.10^{14}				
		≥ 1.10^{14}		≥ 1.10^{14}	≥ 1.10^{14}				
-	V-0		-	V-0	V-0		-	-	
		44		44	44-65[5]		44	44-65[5]	

Electrical properties	
ASTM D 150	
Dielectric constant at 1 MHz	7
Tg delta at 1 MHz	0.2

	VF2 - CTFE COPOLYMERS				PVDF COMPOUNDS			
Hylar®	**Solef®**				**Solef®**			
SN	31008	31508	32008	60512	3108/0903	3110/0907	3208/0150	8808/0902
/ high flexibility dried coatings	High flexibility / High elongation / Cold impact resistance Wire & Cable extrusion			Offshore piping	Anti-static injection	Anti-static extrusion compression molding	Anti-friction injection	Carbon fibers reinforced injection
P & G	P & G			G	G			
1.78	1.76	1.75	1.75	1.77	1.83	1.78	1.8	1.78
< 0.04	< 0.04				< 0.07	< 0.07	< 0.04	< 0.05
-	-			3	-	-	-	-
-	15			1	4.5	2.5	24	9
45	5			-	1.5	-	8	3
10 (1450)	14-35 (2030-5075)			35-40 (5075-5800)	56-60 (8120-8700)	45-60 (6525-8700)	52-56 (7540-8120)	-
17 (2500)	14-30 (2030-4350)			35-40 (5075-5800)	40-60 (5800-8700)	35-50 (5075-7250)	40-60 5800-8700)	80-120 (11600-17400)
20	10-12				3-5	2-5	5-7	-
600	350-600			100-350	20-30	20-50	20-50	1-4
200 (29000)	800 (116000)	500 (72500)	390 (56550)	1300 (188500)	4200 (609000)	2400 (348000)	2600 (377000)	8000 (1160000)
-	33 (4785)	18 (2610)	8 (1160)	-	89 (12905)	80 (11600)	78 (11310)	150 (21750)
200 (29000)	850 (123250)	425 (61625)	200 (29000)	-	4500 (652500)	2400 (348000)	2200 (319000)	7500 (1087500)
NS[4]	520 (9.72)[3]	1000 (18.7)[3]	NS[4]	1000 (18.7)[3]	60 (1.12)	110 (2.06)	60 (1.12)	60 (1.12)
38	63	53	47	70	82	77	78	82
5-10	5-15			5-10	5-10			-
0.2-0.4	0.2-0.4				0.2-0.4		<0.2	0.2-0.4
0.2-0.3	0.2-0.3				0.2-0.3		<0.2	0.2-03
106 (223	169 (336)	169 (336)	168 (334)	171 (340)	172 (342)	171 (340)	172 (342)	172 (342)
8 (3.4)	34 (14.6)	26 (11.2)	17 (7.3)	51 (22)	64 (28)	62 (27)	62 (27)	62 (27)
64 (147)	127 (261)	128 (262)	128 (262)	140 (284)	140 (284)	138 (280)	140 (284)	140 (284)
15 (6.4)	32(13.7)	25 (10.7)	19 (8.2)	41 (17.6)	58 (25)	56 (24)	58 (25)	58 (25)
-	140 (284)	110 (230)	75 (167)	167 (333)	168 (334)	168 (334)	168 (334)	172 (342)
-	82 (180	49 (120)	48 (118)	140 (284)	152 (306)	145 (293)	148 (298)	170 (338)
-	48 (118)	36 (97)	-	64 (147)	115 (239)	93 (199)	115 (239)	158 (316)
-41 (-42)	-30 (-22)	-28 (-18)	-28 (-18)	-28 (-18)	-	-32 (-26)	-40 (-40)	-35 (-31)
-	-30 (-22)	-37 (-35)	-53 (-63)	-31 (-24)	0-10 (32-50)	-5 to +5 (23 to 41)	0-10 (32-50)	>0 (>32)
-	2-3					2-3		0.5-1
-370 (644-698)	320-350 (608-662)	320-340 (608-644)			300-350 (572-662)	375-400 (707-752)	375-400 (707-752)	300-400 (626-752)
-230 (117-128)	130-150 (72-83)			130-180 (72-100)		120-140 (67-78)		70-90 (39-50)
0.16 (1.1)	0.18 (1.2)			0.2 (1.4)	0.3 (2.1)	0.3 (2.1)	0.2 (1.4)	0.33 (2.3)
1.3 (0.31)	1.2-1.6 (0.28-0.38)				-	-	-	-
≥ 1.10^{14}	≥ 1.10^{14}				<1.10^{3}	<1.10^{3}	≥ 1.10^{14}	<10^{5}
≥ 1.10^{14}	≥ 1.10^{14}				<1.10^{3}	<1.10^{3}	≥ 1.10^{14}	<10^{4}
V-0	-	V-0	-	-	-	V-0	-	V-0
44	44-65[5]	48-65[5]	50-65[5]	-	-			

7	7
0.2	0.2

Solvay Solexis S.p.A.
Viale Lombardia, 20
20021 Bollate (MI), Italy
Tel. +39 02 3835 1
Fax +39 02 3835 2129

Solvay Solexis Inc.
10 Leonard Lane
Thorofare NJ 08086, USA
Tel. +1 856 853 8119
Fax +1 856 853 6405

www.solvaysolexis.com

SOLVAY

a Passion for Progress®

Design: www.blisscommunication.be
TR2001C-B-05-1106