KUREHA

KF POLYMER

Poly(vinylidene fluoride) (PVDF)

KUREHA CORPORATION

http://www.kureha.co.jp/

Contents

KF POLYMER

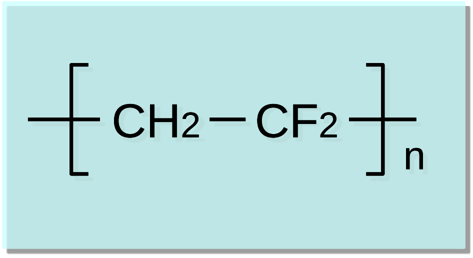
Poly(vinylidene fluoride) (PVDF)

KUREHA KF Polymer is poly(vinylidene fluoride) (PVDF), which has been produced industrially by KUREHA since 1970. KF Polymer is a flame retardant engineering thermoplastic with excellent fluoropolymer performance. It has excellent processing characteristics, similar to those of conventional polymers. KF Polymer is being used in applications where heat resistance, corrosion resistance and weatherability are required. KF Polymer is used for lithium ion batteries (as a binder material), membranes for water treatment, fishing lines, strings of various stringed instruments and for chemical valves along with other injection molded and extruded items.

Features of KF POLYMER

- KF Polymer is one of the easiest processing fluoropolymer materials. It can be processed by injection molding, extrusion and welding.
- KF Polymer is a high purity resin with very low levels of extractables (TOC: total organic carbon, metal, and metal ions). KF Polymer is processed without additives such as plasticizers or heat stabilizers. Please consult us if additives such as fillers, colorants, processing aids or other chemical substances are required. Some additives may cause unexpected decomposition. In the case of using new additives, mixing test is strongly recommended.
- KF Polymer has excellent chemical resistance in a wide range of chemicals and maintains its properties. (Refer to p.10-11 "KF Polymer chemical resistance table" about applicable chemicals and conditions.)
- KF Polymer excels in heat resistance and weather resistance and is stable when exposed to ultraviolet or radioactive rays compared to conventional polymers.
- KF Polymer is one of the best fluoropolymers in terms of mechanical properties, such as aburation resistance and impact resistance.
- KF Polymer has unique ferroelectrical characteristics and is applied to various piezoelectric-sensors and pyroelectric-sensors.

Structure of KF POLYMER



PVDF's polymer chain has a structural formula of -(CH_2-CF_2)$_n$-. The polarity of PVDF originates from its molecular structure; CH_2 unit is an electron donor and CF_2 unit is an electron acceptor. The PVDF polymer chains are composed of Head-to-Tail bonding -CH_2-CF_2-CH_2-CF_2-, Head-to-Head bonding -CH_2-CF_2-CF_2-CH_2- and Tail-to-Tail bonding -CF_2-CH_2-CH_2-CF_2-. Head-to-Tail bonding is designated as regular bonding. KF Polymer has a high regular bonding ratio and linear structure. Its crystallinity and melting point are higher than those of other commercial PVDF. Crystallinity range is from 30% to 50%.

PVDF shows various crystalline structures noted as α-phase, β-phase and γ-phase. Representations of these crystalline structures are shown in Fig. 1. PVDF ordinarily forms α-phase from molten state. In α-phase, PVDF chains have polarity and stack in anti-parallel manner. Anti-parallel stacking leads to non-polar nature of α-phase crystal. β-phase crystal is formed by cold-drawing of α-phase crystal. In β-phase crystal, PVDF chains have polarity and stack in parallel formation. Consequently, β-phase crystal has the largest dipolar-moment and is used for ferroelectric applications. γ-phase crystal is produced by heat treatment of α-phase crystal. γ-phase crystal has polarity similar to β-phase crystal.

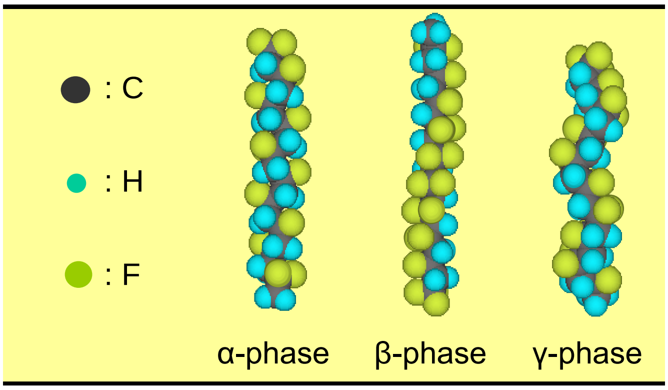


Figure 1: Crystalline structure

Line-up and Properties of KF Polymer

Properties	Units	Test method	Conditions	Grade						
				850	1000	1100	1300	1550	1700	2950
Type	-	-	-	Homopolymer						Copolymer
Feature Main molding methods	-	-	-	Low MV Injection molding	Low MV Injection molding & Extrusion	Medium MV Extrusion	High MV Higher mechanical properties Extrusion	High MV Higher mechanical properties Extrusion	Ultra high MV Higher mechanical properties Extrusion	Low MV Low elution properties Extrusion
Main application	-	-	-	Valve, Pipe	Pipe, Film, Fiber	Film, Fiber	Film, Fiber, Membrane	Membrane	Membrane	Pipe, Tube (Super-high purity use)
Form	-	-	-	powder, pellet				powder		pellet
Physical properties										
Specific gravity	g/cm^3	ASTM D792		1.77 - 1.79						
Inherent viscosity	dl/g	ISO 1060-1	30℃,DMF	0.85	1.00	1.10	1.30	1.50	1.70	1.05
Refractive index	-	ASTM D542	25℃	1.42						
Water absorption	%	ASTM D570	23℃	0.03						
Melt viscosity	Pa･s	ASTM D3835	240℃,50sec^{-1}	1200	2200	3300	5000	-	-	2700
			260℃,50sec^{-1}	-	-	2500	4500	6500	8500	-
Melt flow rate	g/10min	ASTM D1238	230℃,5kg	18-26	6-9	2-4	0.8-1.4	-	-	4-8
			230℃,21.6kg	-	-	-	11.2	3.8	1.7	-
Thermal properties										
Melting point	℃	ASTM D3418		173	173	173	173	173	173	172
Crystallization point	℃	ASTM D3418		140	140	140	140	140	140	146
Glass transition point	℃	DMA method		-35						
Brittleness temperature	℃	ASTM D746		-13	-31	-37	-47	-	-	-30
Vicat softening temperature	℃	ISO 306	50℃/h,10N	171	172	172	173	-	-	166
Coefficient of linear expansion	$10^{-4}K^{-1}$	ISO 11359-2	RT-80℃	1.6						
Thermal conductivity	W/m･K	ASTM E1530	23℃	0.17						
Specific heat capacity	J/g･K	JIS K7123	23℃	1.2						
Mechanical properties										
Izod impact strength	kJ/m^2	ASTM D256	20℃	7.9	15	33	77	-	-	14
		V-notched	0℃	5	9.7	13.3	37	-	-	8.2
		(ISO180)	-20℃	3	3	3.4	11.5	-	-	3
			-40℃	3	2.7	2.9	3.6	-	-	2.8
Shore hardness	D	ISO 868	23℃,50N	78	78	79	78	-	-	77
Tensile strength at yield	MPa	ISO 527-2		57	57	59	67	-	-	54
Tensile elongation at break	%			76	28	36	25	-	-	29
Tensile modulus	MPa			2510	2330	2430	2580	-	-	2120
Flexural strength	MPa	ISO 178		75	74	71	70	-	-	67
Flexural modulus	MPa			1990	1570	1500	1870	-	-	1760
Compressive strength	MPa	ISO 604		76	74	71	68	-	-	65
Compressive modulus	MPa			1700	1570	1500	2020	-	-	1770
Abrasion resistance	$10^{-6}kg$	Taber CS-17	1kg,1000rev	31	31	31	31	-	-	32
Electrical properties										
Volume resistivity	Ωcm	ASTM D257		10^{14-15}						
Surface resistance	Ω/□	ASTM D257		$>10^{15}$						
Breakdown strength	MV/m	ASTM D149	Thickness: 34μm	300						
Dielectric constant		ASTM D150	1kHz	10	10	10	10	-	-	10
Dissipation factor		ASTM D150	1kHz	0.015	0.015	0.015	0.015	-	-	0.02
Flame resistance										
Burning rate		UL94		V-0 equivalent	V-0	V-0 equivalent	V-0	V-0 equivalent	V-0 equivalent	V-0 equivalent
Limiting oxygen index	%	ISO 4589-2	TYPE-IV	44						

Technical Notes

Mechanical Properties

The glass transition temperature of KF Polymer is about -35°C, and its crystallinity is high. It shows good mechanical properties compared to other fluoropolymers. Crystallization speed is high (see thermal properties on p.8), and dimensional stability of mold can be improved by annealing at 80-150°C.

Tensile properties (ISO527-2)

Tensile strength decreases as temperature increases. Even at 100°C, tensile strength is about 35MPa or more.

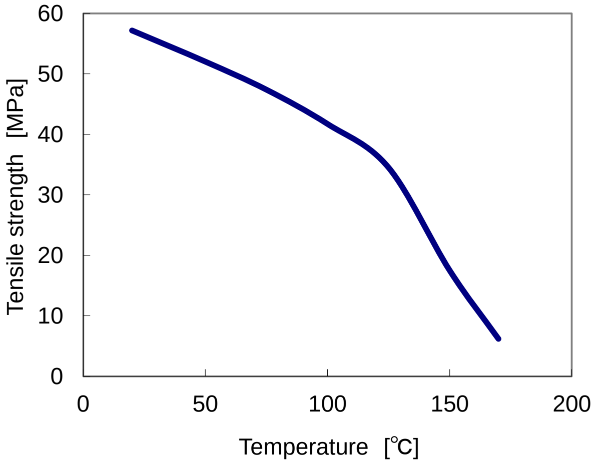


Figure 2: Tensile strength (KF 1000)

Tensile creep (ASTM D2990, 10MPa)

PVDF exhibits fine creep resistance, unlike other fluoropolymers that typically show large tensile creep.

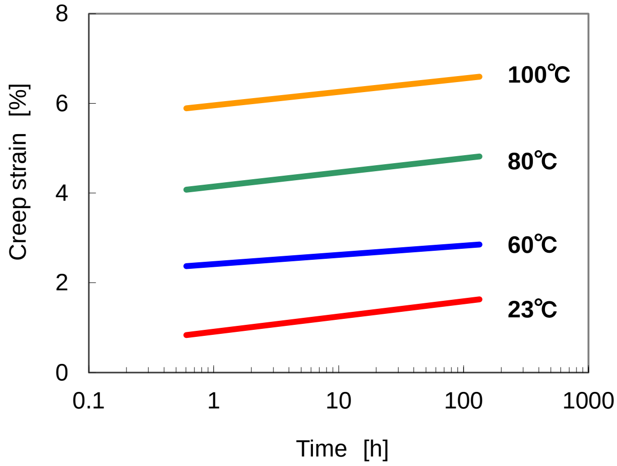


Figure 3: Tensile creep (elongation) (KF 1000)

Tensile creep (ISO899-1 23°C, 8MPa)

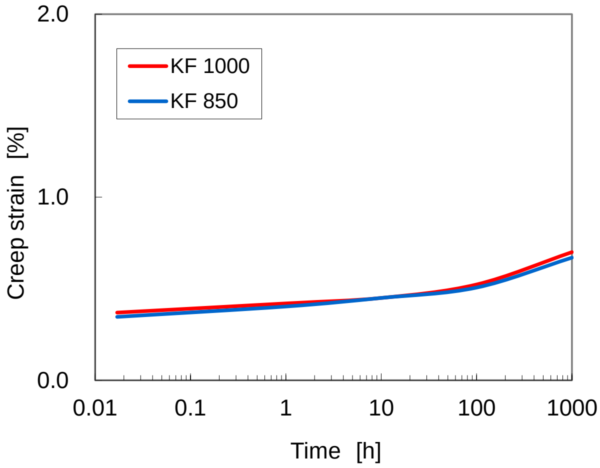


Figure 4: Tensile creep

Flexural Creep (ISO899-2 23°C, 8MPa)

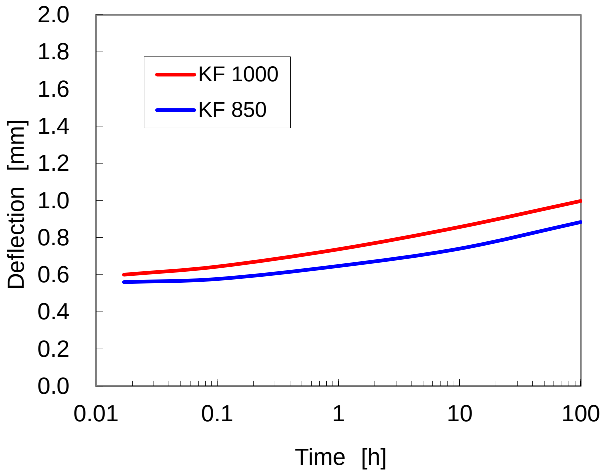


Figure 5: Flexural creep

Melt viscosity (Shear rate=100sec^{-1})

Suitable processing temperature of KF Polymer is 200-240°C.

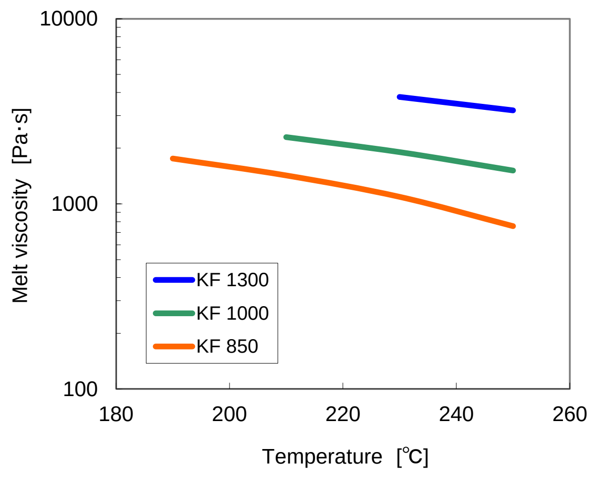


Figure 6: Melt viscosity

Izod impact strength (ASTM D256 (notched))

KF Polymer shows good Izod impact strength even at low temperature.

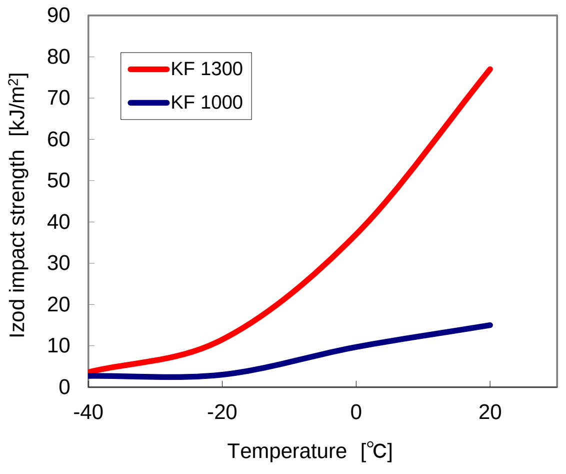


Figure 7: Izod impact strength

Dynamic viscoelasticity (Heating rate: 2°C /min, 10Hz)

The peak which indicates glass transition appears at -35°C. Exceeding the glass transition temperature, elastic modulus (E') gradually decreases.

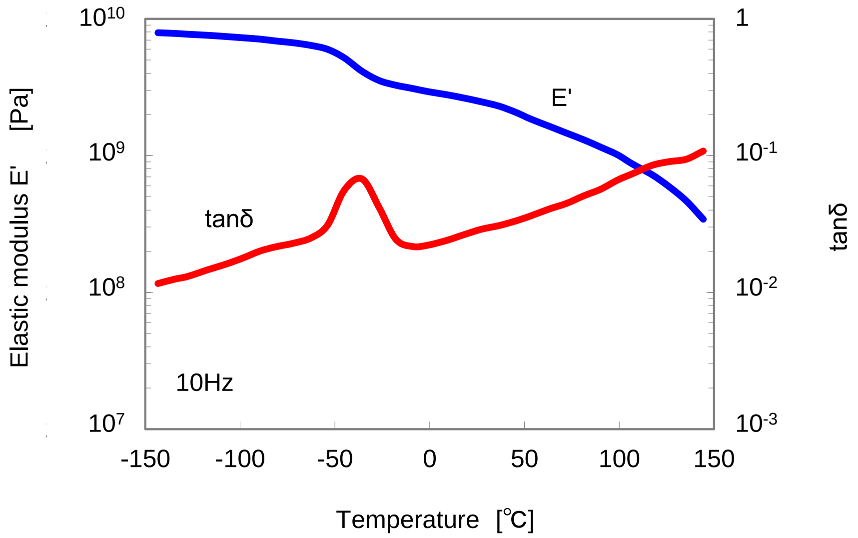


Figure 8: Viscoelasticity (KF 1000)

Thermal Properties

KF Polymer (homopolymer) has a glass transition temperature (Tg) at -35°C measured by the DMA (dynamic mechanical analysis). KF Polymer without any additives has flame retardance meeting UL94V-0 or equivalent and LOI (limiting oxygen index) value of 44.

Melting point & Crystallization point (DSC, ASTM D3418)

The melting point of KF Polymer (homopolymer grade) is 175°C. The crystallization point is 145°C. Since crystallization rate is rapid, cold crystallization is not usually observed. The melting point of copolymer grade is slightly lower than that of homopolymer grade.

Thermal decomposition (TGA, ISO 11358)

The decomposition begins at about 360°C. However, if KF Polymer is held at elevated temperature for an extended time, thermal decomposition can occur below 360°C. At the time of processing, PVDF should not be left over 280°C for a long periods.

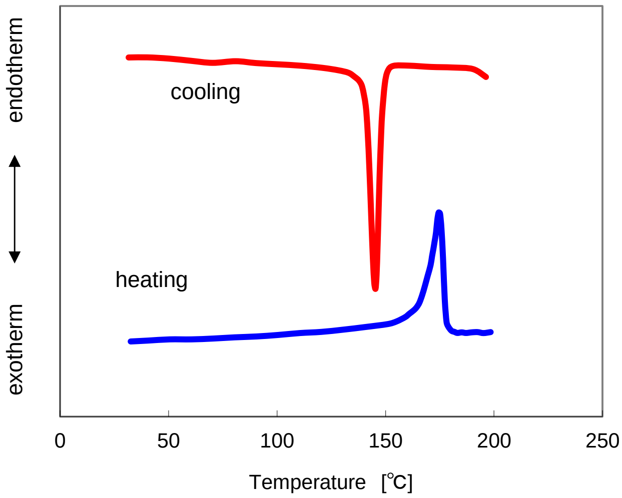


Figure 9: The behavior of melting point and crystallization point (KF 1000)

(Heating or cooling rate: 10°C /min in N_2)

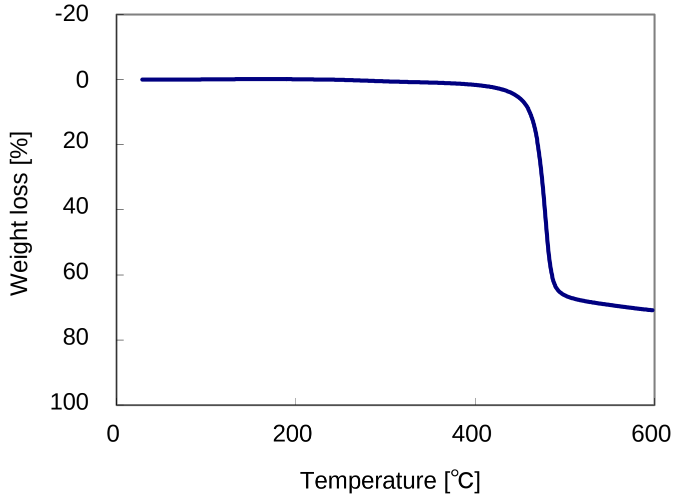


Figure 10: Thermogravimetric analysis (KF 1000)

(Heating rate: 10°C /min in N_2)

Electrical Properties

Since KF Polymer has a very large dipole moment, the dielectric constant is very high. A measured value is around 10 for non-oriented material. In general, dielectrics which have high dielectric constant show low volume resistivity, but KF Polymer maintains high insulation. Similarly, dielectric breakdown strength is high, but dissipation loss (about 0.013) is comparatively large.

Frequency dispersion (ASTM D150)

The loss tends to be large in the region of high frequency.

Temperature dispersion (Heating rate: 2°C /min)

The glass transition temperature measured by dielectric constant is -35°C as well as dynamic viscoelasticity. The dielectric constant is about 3 in glass state, where molecular motion is restricted. When the molecular motion is free, the dielectric constant is very high. The peak which is regarded as crystalline dispersion exists around 80°C.

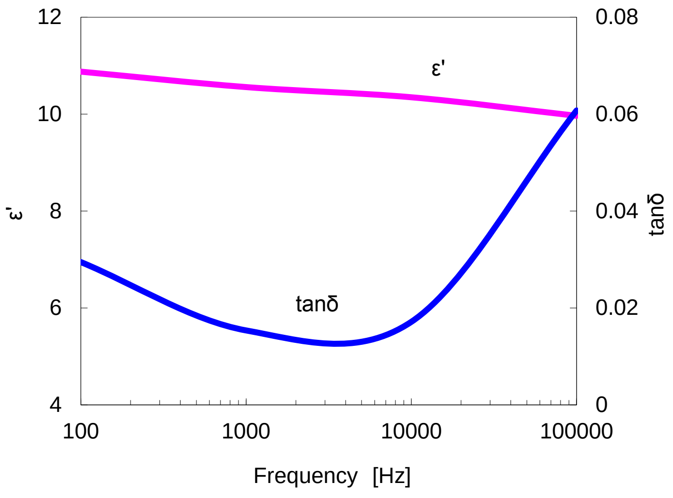


Figure 11: Dielectric constant and Frequency dispersion (KF 1000) at 23°C

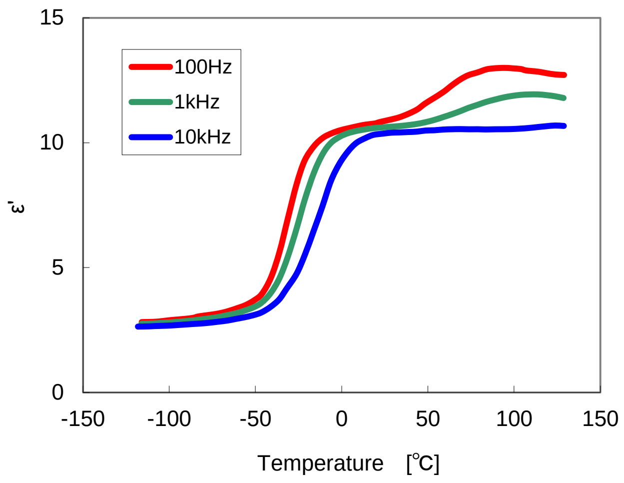


Figure 12: Dielectric constant (KF 1000)

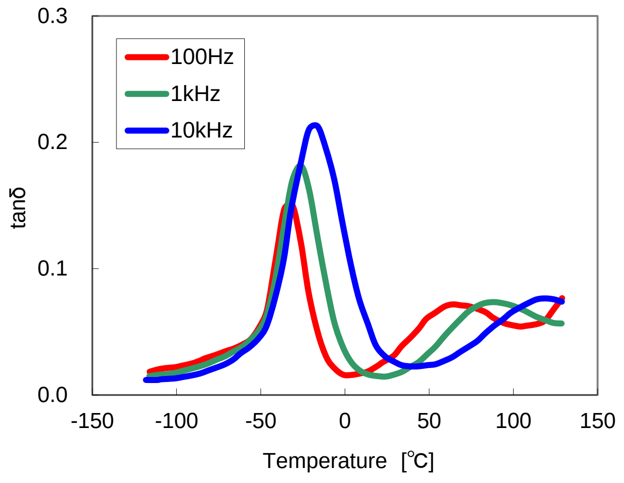


Figure 13: tanδ (KF 1000)

Chemical Properties

Since KF Polymer has strong polarity, it may be attacked by some polar solvents. Even if significant discoloration is caused by alkali and amine compounds, remarkable deterioration of mechanical properties are not seen. KF Polymer has good resistance to acids. However, it can be attacked by certain strong acids (fuming sulfuric acid, fuming nitric acid). KF Polymer can be used in contact with hydrocarbons, organic acids, alcohols, and chloro-hydrocarbons, but it may swell or partially dissolve in basic amines, highly polar esters, ketones, ethers and amides. Examples of polar solvents dissolving KF Polymer are NMP (N-Methyl-2-pyrrolidone), DMF (Dimethyl formamide), DMA (Dimethyl acetamide) and DMSO (Dimethyl sulfoxide).

Evaluation method

- Sample; KF Polymer sheet 50mm×50mm×2mm
- Immersion time; over 1000 hours until weight increase is saturated
- The criteria value of weight gain; 3.0mg/cm^2 for inorganic chemicals, 7.0mg/cm^2 for organic chemicals
- Criteria;

1 No appearance change

The weight gain reaches saturation below the criteria value without any appearance change.

2 Appearance slightly changes but still usable

The weight gain reaches saturation slightly below the criteria value with little change.

3 Needs special attention for use

The weight gain reaches saturation above the criteria value, with some appearance change.

4 Appearance severely changes and not recommended for use

The weight gain does not reach saturation with dissolution or crack /craze.

(Note) Appearance changes include crack and craze without color change.

KF Polymer chemical resistance table (1)

		Temperature [℃]							Chemical formula
		25	50	65	80	100	110	120	
Inorganic acid	Hydrochloric acid (35%)	1	1	1	1	2	2	3	HCl (35%)
	Hydrogen chloride (gas)	1	1	1	1	1			HCl (gas)
	Chlorine (dry)	1	1	1	1	1			Cl_2 (dry)
	Hydrogen peroxide (30%)	1	1	1	1				H_2O_2 (30%)
	Chromic acid (50%)	1	1	1	2	3			$CrO_3 + H_2O$
	Hydrogen cyanide (gas)	1	1	1	1	1	1	1	HCN (gas)
	Hydrobromic acid (50%)	1	1	1	1	1			HBr (50%)
	Bromine (wet)	1	1	1	1	1			Br_2 (wet)
	Nitric acid (60%)	1	2	2	3	4			HNO_3 (60%)
	Carbonic acid	1	1	1	1	1	1	1	H_2CO_3
	Hydrofluoric acid (35%)	1	1	1	1	1	1	1	HF (35%)
	Hydrogen sulfide (dry)	1	1	1	1	1	1	1	H_2S (dry)
	Sulfuric acid (60%)	1	1	1	1	2	2	3	H_2SO_4 (60%)
	Phosphoric acid (30%)	1	1	1	1	1	1	1	H_3PO_4 (30%)

KF Polymer chemical resistance table (2)

		Temperature [℃]							Chemical formula
		25	50	65	80	100	110	120	
Organic acid	Acetic acid (50%)	1	1	1	1	2	3	3	CH_3COOH (50%)
	Acetic anhydride	3	4						$(CH_3COO)_2O$
	Cresol	1	1	2	2	3			$C_6H_4(CH_3)OH$
	Phenol (10%)	1	1	1	1	2			C_6H_5OH (10%)
Alkali	Aqueous ammonia (30%)	1	1	1	1	1			$NH_3 + H_2O$ (30%)
	Sodium hydroxide (10%)	1	1	2	2	3			NaOH (10%)
	Sodium carbonate	1	1	1	1	1	1	1	Na_2CO_3
Hydrocarbon	Methane	1	1	1	1	1	1	1	CH_4
	Propane	1	1	1	1	1	1	1	$CH_3CH_2CH_3$
	Hexane	1	1	1	1	1	1	1	$CH_3(CH_2)_4CH_3$
	Heptane	1	1	1	1	1	1	1	$CH_3(CH_2)_5CH_3$
	Octane	1	1	1	1	1	1	1	$CH_3(CH_2)_6CH_3$
	Cyclohexane	1	1	1	1	1	1	1	C_6H_{12}
	Benzene	1	2	2	2	3			C_6H_6
	Toluene	1	1	2	2	3			$C_6H_5(CH_3)$
	Xylene	1	1	1	1	1			$C_6H_4(CH_3)_2$
Halogenated Hydrocarbon	Butyl chloride	1	1	1	1	1	1	1	C_4H_9Cl
	Trichloroethylene	1	1	1	1	1	1		$Cl_2C=CHCl$
	Ethylene dichloride	1	1	1	2	2	2		$ClCH_2CH_2Cl$
	Perchloroethylene	1	1	1	1	1	1		$CCl_2=CCl_2$
	Monochlorobenzene	1	1	1	1	2			C_6H_5Cl
	Ethylene bromide	1	1	1	1	2	2		$BrCH_2CH_2Br$
	Butyl bromide	1	1	1	1	1	1	1	C_4H_9Br
Alcohol	Methanol	1	1	1	1	1	1	1	CH_3OH
	Ethanol	1	1	1	1	1	1	1	C_2H_5OH
	Propanol	1	1	2	2	3			C_3H_7OH
	1-Butanol	1	1	1	1	1	1	1	$CH_3(CH_2)_3OH$
	2-Butanol	1	1	1	1	1	1	1	$CH_3CH_2CH(OH)CH_3$
Ester	Ethyl acetate	2	3						$CH_3COOC_2H_5$
	Butyl acetate	1	2	3	4				$CH_3COOC_4H_9$
Ketone	Acetone (50%)	2	3	4					CH_3COCH_3 (50%)
	2-Butanone	2	3	4					$CH_3COCH_2CH_3$
	Cyclohexanone	1	3	3	4				$C_6H_{10}O$
Amine	Dimethyl amine	2	3	4					$(CH_3)_2NH$
	Triethyl amine	1	3	3	4				$(C_2H_5)_3N$
	Aniline	1	2	2	2	3			$C_6H_5NH_2$
Aldehyde	Benzaldehyde	2	3						C_6H_5CHO
	Formaldehyde (37%)	1	1						HCHO (37%)
	Salicylaldehyde	1	2	3					$C_6H_4(OH)(CHO)$
Ether	Diethylether	1	2						$(C_2H_5)_2O$
	Dioxane	3	3	4					$C_4H_8O_2$
	Ethylene oxide	2	3	4					C_2H_4O
Cyanide	Acetonitrile	1	1	3					CH_3CN

Ozone Resistance Properties

Ozone resistance properties of KF Polymer are very good compared with High Density Polyethylene (HDPE).

(Exposure conditions; 1.0-1.2% Ozone,

Room temperature.

Sample thickness=0.15mm,

Sample width=5mm,

Testing length=20mm,

Tensile speed=1.0mm/min.)

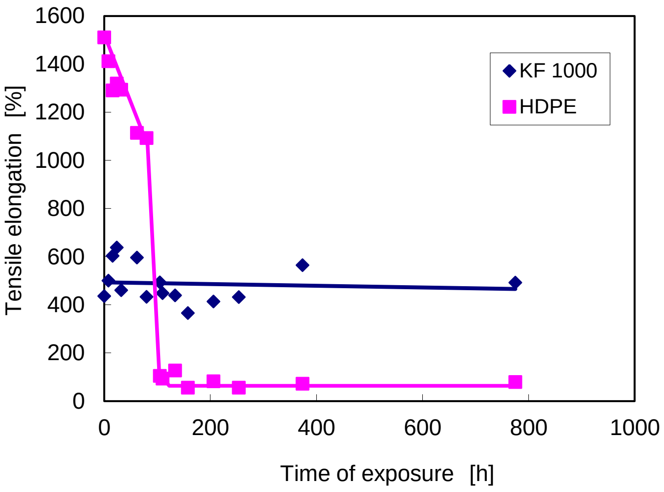


Figure 14: Tensile elongation of KF polymer after Ozone exposure

Elution of Impurities

KF Polymer is inherently pure and applied to parts for ultrapure water piping system.

Elution of total organic carbon (TOC) (95°C hot water, 6 days)

	Unit	Homopolymer			Copolymer
		850	1000	1100	2950
TOC	μg/g	1.6-2.3	1.6-2.2	1.6-2.2	1.2-1.8

*Specimen form: pellets

Content of Trace Metals

KF Polymer contains very low level of metals.

Content of trace metals of KF Polymer (Neutron Activation Analysis) (KF 1000)

Element	Content [μg/g]	Element	Content [μg/g]	Element	Content [μg/g]	Element	Content [μg/g]
Na	0.07	Zn	<0.1	Mo	<0.02	Ba	<0.3
K	<0.1	Ga	<0.001	Ag	<0.02	La	<0.001
Sc	<0.0003	As	<0.001	Cd	<0.03	W	<0.001
Cr	<0.03	Se	<0.03	In	<0.0003	Ir	<0.002
Fe	<3	Rb	<2	Sn	<2	Au	<0.0001
Co	<0.01	Sr	<0.2	Sb	<0.001		
Ni	<3	Zr	<0.3	Cs	<0.005		

Gas Barrier Properties

Water Vapor Transmission Rate (WVTR) of KF Polymer (ISO 15106-2)

WVTR of KF Polymer is very low compared with other plastics.

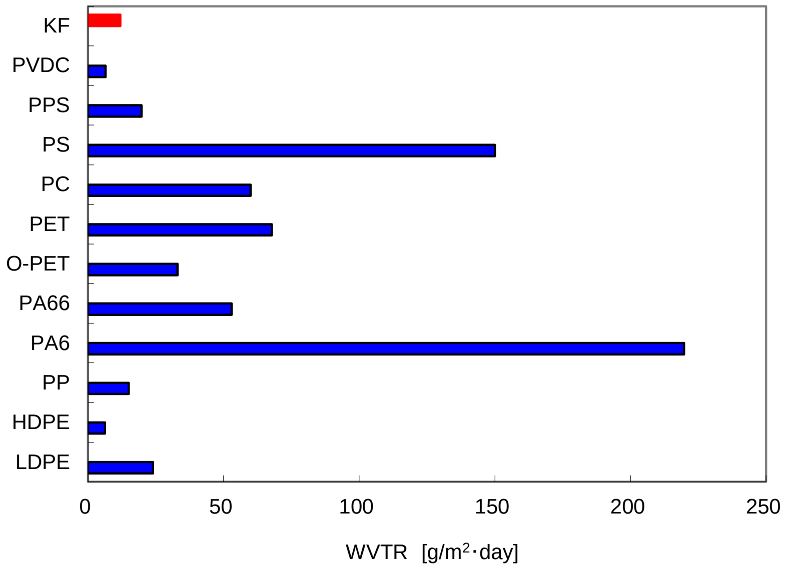


Figure 15: WVTR of KF Polymer and other polymers (Film thickness: 20μm, 40°C 90%RH)

Gas Barrier properties of KF Polymer

Gas Barrier properties (oxygen, carbon dioxide) of KF Polymer are superior to those of other commodity thermoplastics, and bear comparison with other engineering plastics

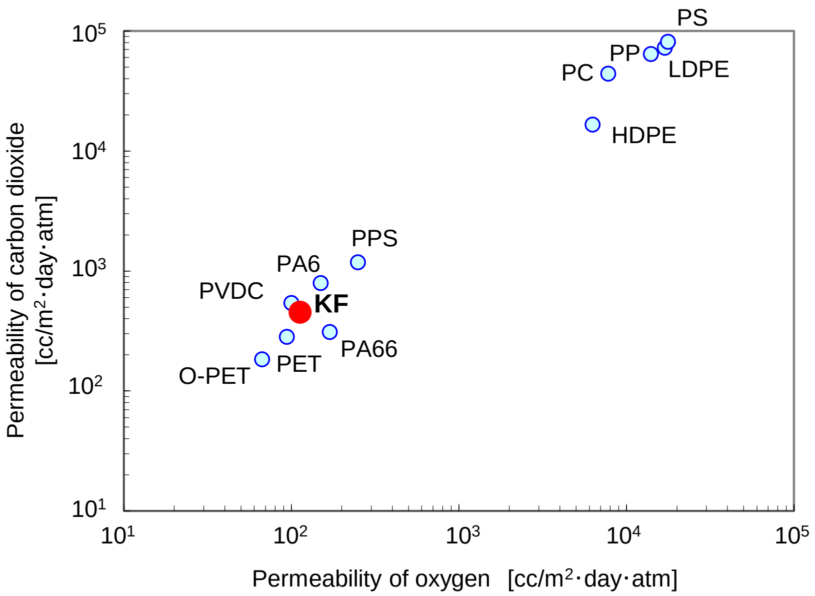


Figure 16: O_2 and CO_2 permeability of KF Polymer and other polymers (Film thickness: 20μm, 30°C, 80%RH)

Optical Properties

Ultraviolet and Visible transmission

As a film (thickness=100μm), visible light transmittance (parallel light transmission) is about 60%. It is possible to increase light transmittance by thinning film (2-axis extension film, etc.). Thick parts such as molded items have an opaque white appearance due to optical dispersion by fine crystals.

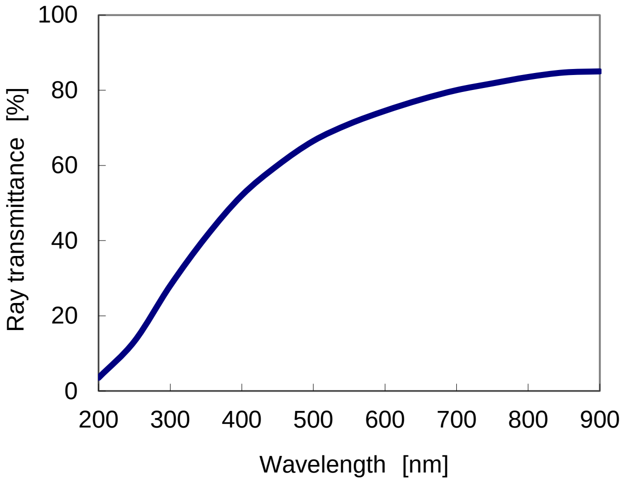


Figure 17: UV-VIS Spectrum of KF Polymer
(KF 1000, Film thickness: 100μm)

Weatherability

Weatherability of KF Polymer (mechanical properties)

KF polymer has excellent weatherability. Therefore, it has been used as a transparent antifouling film material for the outdoors.

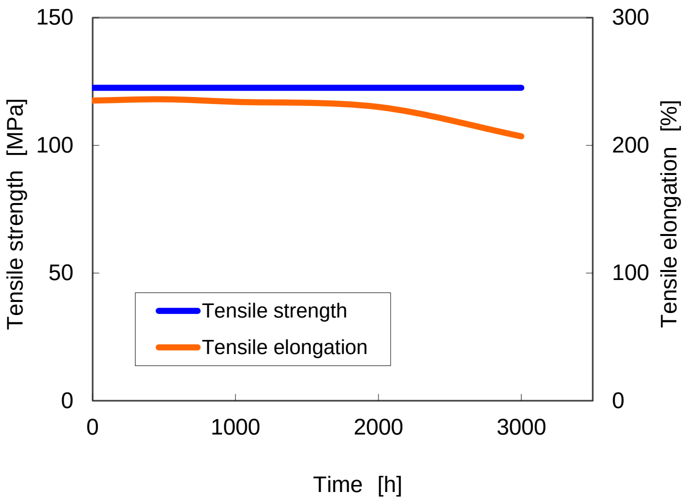


Figure 18: Weatherability test
- tensile strength and elongation

Exposure condition: Weatherometer, Carbon-arc lamps,
Cycle: 12min spray / 60min stop, 63±3°C, 50-60%RH
Sample: KF 1000, Film thickness: 35μm

Weatherability of KF Polymer (optical properties)

The optical properties of KF Polymer are affected only by outdoor exposure slightly. KF Polymer is used as various kinds of cover films.

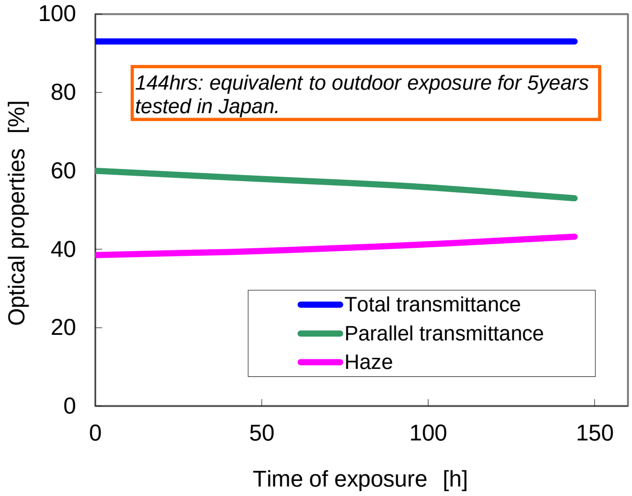


Figure 19: Weatherability test - optical properties

Exposure condition: Super UV tester, Fluorescent UV lamps,
0.83W/cm2, Black panel temp.: 63°C, 60%RH
Sample: KF 1000, Film thickness: 100 μm

Handling of KF Polymer (Remarks)

Handling

Do not use or heat PVDF at temperature over 360°C. If concerned, set up local ventilation equipment and provide sufficient ventilation to avoid inhalation of generated gas.

Since the products are easy to be charged, take care not to scatter them around the area during handling. If necessary, take implementation of antistatic control measures for equipment.

Depending on the type of inorganic materials added to KF polymer as pigments or for compounds, it decomposes rapidly by the application of heat and generates large amount of hazardous decomposition products. Glass fiber, titanium oxide, etc. are known to have decomposition effect. If molten resin contacts with an alloy containing boron, there is a risk of explosion caused by abnormal decomposition.

KF Polymer has self-extinguishing character for flame retardance properties, but it will decompose when it is continuously exposed to extremely high heat of combustion fire, etc. Whenever any fire breaks out, perform fire-extinguishing activities. There is no limitation for usable fire-extinguishing agent.

KF Polymer is judged to be non-explosive in the dust explosion examination.

- ❑ Minimum limiting concentration measurement

Test specification;	The specification of The Association of Powder Process Industry and Engineering, Japan. APS002-1991
Testing equipment;	Upwash type dust explosion examination equipment (Amano Corp.)
Sample;	KF Polymer W1000
Result;	Non-explosive in 1,200g/m^3 or less

- ❑ Minimum ignition energy measurement

Testing equipment;	Upwash type dust explosion examination equipment (Amano Corp.) Minimum ignition energy equipment (SIZUKI ELECTRIC CO.,INC.)
Sample;	KF Polymer W1000
Result;	Non-explosive (2,000mJ or less in the range of 1,000-2,000g/m^3)

Storage

Store at an indoor place which doesn't occur dew condensation without direct sunlight in order to maintain product performance.

Please refer to the Safety Data Sheet (SDS) for more details regarding the proper handling of KF Polymer.

Processing of KF Polymer

General matter

KF Polymer can be molded with the conventional equipment used for commodity crystalline polymers, such as polyethylene and polypropylene. However, temperature control of molten resin, including self-shearing heat generation, is important. Overheated polymer causes heat decomposition and results in generating corrosive gases. Decomposition occurs over 360°C clearly. Keep in mind that decomposition may occur at lower temperatures exposed for an extended time (See p. 8 Thermal Properties Section). Contact with catalytic substances, such as glass fiber, titanium oxide and alloy containing boron etc., may cause decomposition as well.

KF Polymer absorbs very little water, and crystallization proceeds well at room temperatures. Heat treatment for drying and crystallization is generally unnecessary. However, when materials are wet with water, they should be dried for 2-4 hours at 100°C.

Recycled pellets of KF polymer could be used. The maximum content of recycled KF polymer should be 20% by weight. It might be necessary to reduce recycled KF polymer content when molded component is discolored.

The installation of an exhaust system at the processing machine is recommended. Decomposition gas may be generated when molten resin temperature is increased and molten resin stays in process. Decomposed compounds are hydrogen fluoride, carbon monoxide, carbon dioxide, etc.

Direct flame must be avoided to heat and to clean polymer residues on tools, such as a screw, mold, etc.

Selection of resin

Please select resin grade in accordance with your application, or processing method. Melt flow rate (MFR) of resins are helpful for grade selection. Since the impact strength of KF Polymer (non-reinforced grade) is not so high, please create a manufacturing specification for a product in consideration of mechanical properties and manufacture a mold or processing tools for a product.

Screw

General injection molding machines and extrusion molding machines can be used. Reference values of screw design are shown below:

L/D=20-24, Compression ratio=2-3,

Feed zone=10-14D, Compression zone=3-4D, Metering zone=6-7D

Machine

Hard chromium plated material is recommended for a screw, and stainless steel or nitrided steel for barrel and nozzle. For long campaign production, avoid any alloy in which aluminum, titanium or boron, etc. are contained. The alloy of such light metals may promote resin decomposition and may often cause resin hard to release from molding parts such as a screw or a barrel, etc. You can use a nozzle with usual design, take care of temperature management and prevention of flow retention. Pay similar attention to material of molds as well as barrel and nozzle.

Molding conditions

A barrel temperature for general injection molding should be set as the following condition. Although some adjustment may be needed based on MFR data of resin grade and gate shape, do not raise temperature excessively in order to prevent resin decomposition. If color change appears in molded items, change mold condition, such as gate design modification, temperature control, etc., in order to avoid excessive heat history (including heat generation by shearing) to the resin.

Feed zone;	170°C -190°C
Compression zone;	200°C -220°C
Metering zone;	220°C -240°C
Nozzle;	220°C -240°C

Mold temperature; 90°C -120°C

High viscosity grades (KF1300 or KF1550), generally used for extrusion, is high molecular weight PVDF and low fluidity. Due to such characteristics, High viscosity grades might need to set higher temperature condition than that of lower viscosity grades (KF850 or KF1000). It depends on polymer retention time in the extruder barrel, but melt temperature should not be over 280°C to avoid decomposition of PVDF.

KF1700, which is very high molecular weight PVDF, might have difficulty for general melt extrusion process due to very low fluidity. Ask more details for suitable extrusion condition for your purpose.

Start and finish of molding operation

Starting a production with a thoroughly cleaned molding machine is highly recommended. When changing material to KF Polymer from other materials, fully purge molding machine with HDPE or PMMA. Especially after molding resin containing glass fiber or alkaline inorganic pigment, be careful to prevent contamination of these substances. These contaminants may accelerate decomposition of the PVDF resin. After molding PVDF, the machine should be completely purged with HDPE or PMMA. A commercial purge material should be used after fully purging by HDPE or PMMA.

When aborting the operation temporarily, set the cylinder temperature to about 180°C. Aborting operation for 2-3 hours at this temperature will not cause a severe problem. For a long interruption, be sure to purge resin.

Recycling and Disposal

Recycling

It is basically possible to recycle by repelletizing the processed waste and scrap. Please note to minimize thermal damage given to the resin, and avoid any contamination which may promote decomposition of resin (for example, glass fiber and alkaline inorganic pigment).

Recommended content of recycled material is about 20%. But this level should be decreased if discoloration is occurred in the molded items.

Disposal

In case of disposal of KF Polymer and its products, dispose of in accordance with the laws, regulations, and ordinances on waste disposal.

FAQ

Q1. What temperature is appropriate for processing KF Polymer resin?

A1. Generally 200°C to 240°C is the appropriate processing temperature range. Conditions should be adjusted within this range, as processing temperature is dependent on the equipment and the resin viscosity. Due caution should be exercised in the production and handling of processing PVDF which is occurred rapid decomposition above 360°C. In the case of general injection molding, it is recommended to set conditions to keep temperature of molten resin at 220-240°C in order to minimize discoloration of products.

Q2. At what temperature does KF polymer decompose?

A2. PVDF should not be left over 280°C for a long periods. Rapid decomposition of PVDF occurs above 360°C.

Q3. What are decomposition elements of PVDF?

A3. It is known that hydrogen fluoride, carbon monoxide and fluoro-phosgene are decomposition elements of PVDF. Local ventilation is recommended for melt processing.

Q4. Is any special material required for the processing machine parts?

A4. Special materials like Hastelloy® * are not required for a screw and a barrel in the processing machine. It is recommended that all metal parts contacting with molten PVDF should be completely plated (e.g. hard chrome plating). Damaged plating must be repaired, otherwise they could increase the risks of discoloration and/or decomposition of the molten polymer. Avoid light-metal alloys containing aluminum, titanium, boron etc., for screws and barrels. Light-metals could accelerate decomposition of molten PVDF.

* Hastelloy® is a registered trademark of Haynes International, Inc

Q5. Is pre-drying KF Polymer necessary?

A5. KF Polymer has low water absorption and preliminary drying of resin is not necessary.

Q6. Is annealing of molded products necessary?

A6. It depends on the shape of the products. In the case of thick products, annealing could release residual stress and increase dimension stability. Annealing at 100-120°C for 3 hours is recommended for the products within 50mm thickness. Longer annealing time is recommended for thicker products.

Q7. Is any additive agent such as plasticizers or heat stabilizers required?

A7. No. When you use additives like chemical substances, coloring agents, fillers etc. unexpected decomposition may occur. For safety, it is recommended to conduct stability test prior to processing.

Q8. Are there any recommended coloring agents?

A8. KFM color master batches, products of Kureha, are recommended.

Q9. Does KF Polymer contain impurities?

A9. Trace levels (in the range of ppm) of impurities may be delivered from catalyst, but the quantity is pretty small. (See p.12 Elution of Impurities and Content of Trace Metals)

Q10. How about resistance to chemicals?

A10. PVDF may be decomposed by strong acids, though it is tolerant to common acids. On the other hand, it is easily affected and discolored by alkalis. (See p.10-11 Chemical Properties)

Q11. How about resistance to oxidizing agents such as ozone and sodium hypochlorite?

A11. It is slightly affected by oxidizing agents for a long term. However, it shows superior resistance to other conventional plastics like HDPE. (See p.10-11 Chemical Properties)

Q12. Why does PVDF get discolored?

A12. Depending on conditions of molding or annealing, changes of polymer chain terminal and/or dehydrofluorination cause conjugated double bonds resulting in discoloring. In the case of discoloring without any decomposition of polymer chains, it has little effect on the polymer performances because there is little structural changes in the polymer.

Q13. What is the difference compared with other fluoropolymers?

A13. PTFE and FEP are soft resins, because they have comparatively small intermolecular force with weak polarity owing to the lack of hydrogen atoms. They have the physical properties peculiar to a fluoropolymer, such as water repellency (hydrophobicity), non-adhesiveness and chemical resistance. PVDF, in spite of a fluoropolymer, is superior in the mechanical properties even above the glass transition point because of its large intermolecular force and crystallinity. PVDF has also adhesiveness and water repellency. So, PVDF shows intermediate physical properties between other fluoropolymers and commodity resins.

Q14. Why does PVDF have a high dielectric constant?

A14. The molecular chain itself has a large dipole moment, because CH_2 and CF_2 bond regularly and alternately. As the glass transition temperature is low (about -35°C), the mobility of molecular chains is high around room temperature, causing the high dielectric constant.

Q15. Can KF Polymer be used for food and medical applications?

A15. Medical applications where KF Polymer directly contacts with a human body and body fluids are not designed. Check safety regulations and legal status at the stage of development of blood, body fluid, medicine and food applications.

Q16. Is KF Polymer compliant with FDA?

A16. Homo-polymer grades of KF Polymer are compliant according to Section 177.2510 of Title 21 of Code of Federal regulations (C.F.R.) of the US.

IMPORTANT NOTICE:

The numerical values set forth in this catalog are typical representative values obtained by using standard examination methods. Such values are not guaranteed and may not be applied under different conditions.

The numerical values set forth in this catalog may be varied with changes of testing methods and conditions.

Please consult with our staff in regards to the physical properties, technical information and values under special conditions which are not indicated in this catalog.

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The Pursuit of Excellence

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