PEEK

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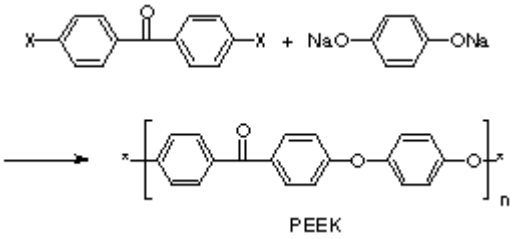
Polyetheretherketones (**PEEK**), also referred to as **polyketones**, are obtained from aromatic dihalides and bisphenolate salts by nucleophilic substitution. The bisphenolate salt is formed *in situ* from bisphenol and either added sodium or added alkali metal carbonate or hydroxide.



PEEK

PEEK is a thermoplastic with extraordinary mechanical properties. The Young's modulus is 3.6 GPa and its tensile strength 170 MPa.

PEEK	
Density	1300 kg/m^3
Young's modulus (E)	3700 MPa
Tensile strength (σ_t)	90 MPa
Elongation @ break	50%
notch test	55 kJ/m^2
Glass temperature	143 °C
melting point	334 °C
Vicat B	-
heat transfer coefficient (λ)	0.25 W/m.K
linear expansion coefficient (α)	1.7 10^{-5} /K
Specific heat (c)	- kJ/kg.K
Water absorption (ASTM)	-
Price	25-50 €/kg

source: [1]

PEEK is partially crystalline, and has a glass transition temperature of 143 °C, a melting temperature of 334 °C and is highly resistant to thermal degradation. The material is also resistant to both organic and aqueous environments, and is used in bearings, piston parts, pumps, compressor plate valves, and cable insulation applications.

PEEK is considered an advanced biomaterial used in medical implants, often in reinforced format using biocompatable fibre fillers such as carbon. Also in carbon fibre reinforced form, PEEK has come under consideration as an aerospace structural material due to its high strength-to-weight ratio.

Chemical resistance

PEEK also exhibits good chemical resistance in many environments, including alkalis (i.e. sodium, potassium and ammonium hydroxides), aromatic hydrocarbons, alcohols (i.e. ethanol, propanol), greases, oils and halegonated hydrocarbons.

However, its performance in acids is very dependent on the type of acid - PEEK shows poor resistance in concentrated sulphiric, nitric, hydrochloric, hydrobromic and other mineral acids (though performance may be adequate for short term use with these acids in very dilute form). Its resistance to hydrofluoric acid and oleum is very poor. PEEK shows good resistance to phosphoric acid and organic acids (acetic, citric, oxalic, tataric etc.), but varying resistance in the presence of halogens. PEEK is resistant to dissolution by some formaldehydes and ketones such as acetone, but not (at higher temperature) methylethyl ketone.

References

1. ^ A.K. vam der Vegt & L.E. Govaert, Polymeren, van keten tot kunstof, ISBN 90-407-2388-5

Summary Of Properties

Extruded Fluoropolymers

The table below lists the generally accepted summary of electrical, mechanical and thermal properties of non-pigmented polymer resins from which ZEUS fabricates its line of tubing, beading, shapes and other unique extrusions.

	PROPERTY	ASTM	UNITS	PTFE	FEP	PFA	ETFE	PVDF	PEEK	LDPE	HDPE
MECHANICAL	Tensile Strength	D1708	PSI	2,500-4,000	3,500	4,000	7,500	D638 5,000	D638 13,300	D638 2,100	D638 4,500
	Specific Gravity	D792		2.13-2.24	2.15	2.15	1.70	1.8	1.32	.92-.94	.95-.97
	Coefficient of Friction	Dynamic (<10 ft/min)		0.1	0.2	0.2	0.23	0.3	0.35 -0.5	0.18	
	Compressive Strength	D695	PSI	3,500	2,200		7,100	11,600	17,100	2,700-3,600	
	Impact Strength 73°F	D256	Ft-Lb/in	3.5	No Break	No Break	No Break	3-6	655	1.0	10
	Flexural Modulus 73°F	D790	PSI	27,000	95,000	95,000	200,000		530,800		100,000
	Tensile Modulus	D638	PSI	80,000	60,000	40,000	120,000	348,000	522,100	38-75	155-155
	Hardness-Durometer	D2240		D-50-65	D-55	D-60	D-75	D-76-80		D50	D64
	Elongation	D1708	%	200-400	300	300	100-300	D638 150	D638 50	D638 425	D638 7,800
	Flexural Strength	D790	PSI	No Break	No Break	No Break	37.9 5,500	10,750	24,700		
	Water Absorption	D570	%	<0.01	<0.01	0.03	<0.03	<0.04	<0.05	<0.01	<0.01
	Deformation Under Load (73°F, 1000 PSI, 24 HR)	D621		3.5	1.8	2.0	0.6				
	Linear Coefficient of Expansion (70-212°F) (212-300°F) (300-408°F)	D696	in/in/°F	 $7.5x10^{-5}$ $8.5x10^{-5}$ $10.5x10^{-5}$	 $4.5\text{-}5.8x10^{-5}$	 $6.7x10^{-5}$ $9.4x10^{-5}$ $11.1x10^{-5}$	 $5.0x10^{-4}$ $7.0x10^{-4}$	 $7.1x10^{-5}$	 $2.6x10^{-5}$	 In/In/°c $2x10^{-4}$	 In/In/°c $1.1x10^{-5}$
	Flex Life (MIT)			>1,000,000	15,000	15,000	12,000				
	Creep Resistance	D674	LB/Sq In			40,000					
ELECTRICAL	Dielectric Strength (ShortTerm) 10Mil Film	D149	V/Mil	>1,400	>2,000	>2,000	>2,000	>1080	>500	450-1000	450-500
	Volume Resistivity	D257	ohm-cm	$>10^{18}$	$>10^{18}$	10^{18}	$>10^{16}$	$>10^{13}$	$>4.9x10^{16}$		
	Surface Resistivity	D257	ohm/Sq	$>10^{18}$	$>10^{16}$	10^{17}	$>10^{14}$				
THERMAL	Continuous Service Temperature		°F	500	400	500	302	235	500	190	248
	Melting Point	DTA	°F	635-650	500-530	575-590	490-535	352	633	350	370
	Thermal Conductivity	C-177	BTU/hr/ft²/°F.in	1.7	1.4	1.32	1.65	1.31	1.2		
	Heat of Fusion		BTU/lb	29-37	11	13	20				
	Specific Heat	C-177	Cal/g/°C								
	25°C 100°C 200°C 275°C			0.23 0.25 0.27 0.29	0.26	0.256 0.283 0.334 0.391	0.46-0.47	.30-.34			
	Low Temperature Embrittlement		°F				-150°				
	Deflection Temperature 66 PSI 264 PSI		°F	 252 131	 138 134	 166 118	 220 160	 235	 285	 220	 340
	Heat of Combustion		BTU/lb	2.200		2,200	8,100				
OTHER	Flammability Rating	UL 94		VO	VO	VO	VO	VO	VO	VO	VO
	Retractive Index	D542		1.35	1.338	1.35	1.40				
	Limiting Oxygen Index			>95	>95	>95	30-31				

The outstanding mechanical properties of PEEK at high temperatures make it suitable for the most demanding applications, but the high cost sometimes limits applications to those where the properties are very necessary. Typical applications are the following:

Automotive: Piston components and bearing linings. These applications are particularly suitable for the carbon fiber reinforced grades where the improved thermal conductivity means that heat is dissipated very quickly.

Electrical engineering: Wire insulation for extremely high temperature applications, cable couplings, and connectors. In some of these applications, PEEK is even better than PTFE or other fluoropolymers because it has a greater resistance to cut-through by sharp edges.

Appliances: Handles and cooking equipment.

Medicine: Prosthetics, instruments, and diagnostics.

Others: Aircraft parts and wire insulation, pump casings and impellers, monofilament for production of woven products for filters, belting, and meshes.

Summary

PEEK is one of the few polymers that can be considered for use as a true metal replacement for high temperature applications. As one of the first designer polymers, the superb range of properties has opened up new and highly demanding markets for plastics. Initially, PEEK was considered an exotic material, but now it is an essential tool in the materials engineer's armory for applications when no other material can meet the requirements. For more information on PEEK as a metal substitute, see Zeus' previous Whitepaper "PEEK vs. Metal: Why Plastic is Better" at **http://www.zeusinc.com/pdf/Zeus_PEEK.pdf**

How Zeus Can Help

With a technical inside and outside sales force backed up with engineering and polymer experts, Zeus is prepared to assist in material selection and can provide product samples for evaluation. A dedicated R&D department staffed with PHD Polymer chemists and backed with the support of a world-class analytical lab allows Zeus an unparalleled position in polymer development and customization.

Since 1966 Zeus has been built upon the core technology of precision extrusion of high temperature plastics. Today, with a broad portfolio of engineered resins and secondary operations, Zeus can provide turnkey solutions for development and high-volume supply requirements.

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