OPTINOVA

Medical tubing for World Class Producers

MATERIALS GUIDE
FOR CUSTOM EXTRUSION

Optinova is a world leader in precision extrusion of tubing for medical applications. Established in 1971, Optinova has developed a world-wide reputation of fulfilling customer expectations; not only with fluoropolymer extrusions, but also with a wide variety of thermoplastics.

FLUOROPOLYMERS

PTFE *PolyTetraFluoroEthylene*

The stability of the carbon-fluorine bond in combination with the very high polarity of the fluorine atom will create the unique properties of the high crystalline PTFE paste fluoropolymer. These properties are unlikely to be beaten by any other plastic material. The physiological inertness of the polymer makes PTFE ideal for medical applications. Since PTFE does not melt, it has to be paste-extruded, followed by sintering to obtain its final properties.

- **Outstanding low friction properties and non-stick characteristics.**
- **Outstanding chemical resistance.**
- **Excellent resistance to aging.**
- **Outstanding continuous service temperature from –200°C up to +260°C.**

THERMOPLASTIC FLUOROPOLYMERS

All thermoplastic fluoropolymers are melt extrudable alternatives to PTFE, and are processed in corrosion-resistant equipment. The various thermoplastic fluoropolymers differ in their molecular structure and number of fluorine atoms. It is this difference that will give them their distinctive properties, whilst still maintaining some of the unique properties of PTFE.

ETFE *Ethylene TetraFluoroEthylene*

ETFE is a copolymer of ethylene and tetrafluoroethylene. ETFE is stiff, tough and has a higher resistance to wear than most fluoropolymers.

- **Excellent non-stick characteristics.**
- **Low liquid permeability.**
- **Good resistance to radiation.**
- **High light transmission.**

FEP *Fluorinated Ethylene Propylene*

FEP is a copolymer of tetrafluoroethylene and hexafluoropropylene with a linear molecule chain. FEP has almost the same characteristics as PTFE and is transparent, even though it is a semi-crystalline polymer.

- **Excellent low friction properties and non-stick characteristics.**
- **Excellent chemical resistance.**
- **Outstanding continuous service temperature from –200°C up to +200°C.**
- **Extremely smooth surface.**

PFA *PerFluoroAlkoxy*

PFA is a transparent perfluoroalkoxy copolymer that is considered to be the thermoplastic fluoropolymer with the closest properties to PTFE, whilst being melt processable.

- **Low friction properties and non-stick characteristics.**
- **Outstanding chemical resistance.**
- **Outstanding service temperatures up to +260°C.**
- **High light transmission.**

PVDF *PolyVinyliDene Fluoride*

PVDF is a polymer of vinylidene fluoride. PVDF is stiffer and has a higher mechanical strength and resistance to wear than ETFE.

- **Good chemical resistance.**
- **Excellent abrasion resistance.**
- **Excellent aging resistance.**
- **Smooth surfaces.**

Our production is performed in a clean-room environment. We are devoted to delivering consistent quality combined with innovation. Important in the industry and fixed in our focus are: tight tolerances, traceability, design service and superior as well as personal customer service.

We offer production capacity, experience and knowledge.

THERMOPLASTIC POLYMERS

Thermoplastic polymers are commonly regarded as “plastics”. They are subgrouped into amorphous and semi-crystalline. The crystalline amount of the polymer depends on the original molecules and the thermal history of the polymer. Amorphous polymers are often transparent and semi-crystalline polymers are opaque. Amorphous polymers melt over a wide temperature range contrary to semi-crystalline polymers that have distinct melting temperatures. One characteristic of thermoplastic polymers is that they return to their original physical structure when cooled after melting.

PE *PolyEthylene*

PE is categorised by the density of the polymer, LDPE (low density), MDPE (medium density) and HDPE (high density). A higher crystallinity will produce a higher density, higher melt temperature, higher strength, and a lower permeability to gases and moisture. Polyethylene is a relatively inexpensive polymer that is widely used in medical applications.

- **Low friction properties (HPDE).**
- **Good chemical resistance.**
- **Service temperature up to +100°C (HDPE).**

PP *PolyPropylene*

PP is a semi-crystalline polymer with wide versatility. PP is rather rigid and is frequently used when slightly better mechanical characteristics than HPDE are required.

- **High fatigue resistance.**
- **Good chemical resistance.**
- **Service temperature up to +100°C.**

EVA, EMA, EBA

Ethylene Vinyl Acetate,
Ethylene Methyl Acrylate,
Ethylene Butyl Acrylate

Copolymers of ethylene and polar monomers (vinyl-acetate, methylacrylate or butylacrylate), are used to produce materials with various properties of stickiness, toughness and impact resistance.

- **Flexible.**
- **High impact resistance.**
- **High toughness.**

POM *PolyOxiMethylene*

POM is a highly crystalline polymer commonly named “acetal”. POM is a very hard, strong, dimension stable, opaque polymer, which is an effect of high crystallinity.

- **Low friction properties.**
- **High strength and hardness.**
- **High wear resistance.**
- **Low absorption and permeability of water.**

PET, PBT *PolyEthylene Terephtalate, PolyButylene Terephthalate*

PET and PBT are two of the most commonly used polyesters. PET has a slow crystallisation process compared to all other polymers. PBT is more flexible and tougher than PET.

- **High strength and hardness.**
- **High dimension stability.**
- **Good chemical resistance.**

PC *PolyCarbonate*

PC is a polyester of carbonic acid that has an amorphous structure to provide transparency. PC is used for its toughness and strength.

- **High strength and toughness.**
- **Good transparency.**
- **High dimension stability.**
- **Extreme impact resistance.**

PA *PolyAmide*

PA is a group of semi-crystalline thermoplastics, often referred to as Nylon®. The number of carbon atoms between the functional amide groups in PA produces different properties of this polymer with names such as PA6, PA11 and PA12 indicating these numbers. Absorption of water decreases with increasing numbers of carbon atoms.

- **High strength, stiffness and hardness.**
- **Good wear resistance.**
- **Service temperature up to +150°C.**

THERMOPLASTIC ELASTOMERS

This is a group between rubber and thermoplastic polymers, called thermoplastic elastomers. These copolymers consist of hard polymer segments in a matrix of soft amorphous polymers. These segments are physically bound to each other, giving the elastic properties. In contradiction to rubber and thermosets, the binding between the molecules is reversible by melting and cooling. Changing the ratio of hard segments in the copolymer will increase or decrease the strength, stiffness and hardness of the polymer.

TPE-E *ThermoPlastic Elastomer Ester*

Ester based thermoplastic elastomer, is a copolymer of polyether-esters or polyester-esters.

- **Hardness ranges from Shore 35D to 74D.**
- **Excellent chemical resistance.**
- **High fatigue resistance.**

TPE-A *ThermoPlastic Elastomer Amide*

TPE-A are copolymers of polyamide with either polyether, polyester or polyether ester. The hard segments in the copolymer are formed by the semi-crystalline polyamide segments in the copolymer. PolyEtherBlock-Amide (PEBA), often referred to as PEBAX®, is a commonly used TPE-A in medical applications.

- **Hardness ranges from Shore 75A to 75D.**
- **High abrasion resistance.**
- **Good biocompatibility.**

TPE-U *ThermoPlastic Elastomer Urethane*

TPE-U is a group of polymers often referred to as PUR, with a very wide range of properties. The two main types of PUR are polyester based (aromatic) and polyether based (aliphatic). The polyether based TPE-U is more elastic, and has a higher resistance to hydrolysis and micro-organisms. The hard segment in the copolymer is of a crystalline nature.

- **Hardness ranges from shore 75A to 75D.**
- **Good biocompatibility.**
- **Softens in vivo.**
- **Excellent abrasion resistance.**

TPE-O *ThermoPlastic Elastomer Polyolefins*

TPE-O, a group of polymer blends mainly comprised of polyethylene, polypropylene and rubber. The TPO is semi-crystalline polymer blend, where polypropylene and polyethylene part constitute the crystalline phase and the rubber for the amorphous phase.

- **Hardness from 40A to 62 D.**
- **High impact resistance.**
- **Good chemical resistance.**

TPE-S *ThermoPlastic Elastomer Styrenic Block Copolymer*

TPE-S, are compounds based on SBS or SEBS. Styrene-butadiene-styrene is based on two-phase block copolymer with hard and soft segments. The styrene end blocks provide the thermoplastic properties and the Butadiene mid-blocks provide the elastomeric properties. SEBS is modified SBS by hydrogenation.

- **Hardness from 45A to 65D.**
- **Good scratch resistance.**

COMPOUND, MANUAL MIXING & FILLER

COMPOUND

Compounding is a process used to incorporate fillers, additives, colorants, and or, blend different polymers or grades of polymers into one material. This process normally consists of dry blending, melting in a single or twinscrew extruder, filtering, homogenising, forming of a strand and pelletising. Compounds are used to obtain good and consistent quality. Compounding provides exceptionally better dispersive consistency for material than hand-blending can.

MANUAL MIXING

A manual mixing is a concentrated mixture of additives, i.e. colour pigments, in a carrier polymer. A manual mixing is often used instead of a compound to decrease cost, where small volumes are required. However, the consistency may not be as good as with a compound.

FILLER

A filler is compounded with the polymer to enhance properties, such as radiopacity. Common fillers in medical applications are Barium sulphate, $BaSO_4$, Bismuth trioxide Bi_2O_3, Bismuth Subcarbonate, $Bi_2O_2(CO_3)$ or Tungsten (W). The level of loading (% by weight) will improve visibility of the component in the body under fluoroscopy (X-ray).

GENERAL SUMMARY OF PROPERTIES

		FLUOROPOLYMERS					THERMOPLASTIC POLYMERS									THERMOPLASTIC ELASTOMERS				
			Thermoplastic Fluoropolymers				Polyolefines			Polyamides										
		PTFE	FEP	PFA	ETFE	PVDF	LDPE	HDPE	PP	PA 6	PA 11	PA 12	POM	PET/ PBT	PC	TPE-U	TPE-A	TPE-E	TPE-S	TPE-O
Tensile strength at break	MPa	20–34	20–28	25–30	40–47	35–50	10–20	25–45	20–460	35–80	40–90	38–60	40–70	30–50	70	25–70	30–62	14–25	5–40	
Elongation at break	%	200–400	300–325	300	230	15–50	350–700	50–1000	10–500	40–300	30–400	50–400	10–200	20–350	50–120	160–750	50–700	200–800	400–1000	700–1000
Flexural modulus	MPa	275–620	550–700	590–700	1200	2100	100–600	500–1500	900–2000	500–2900	400–1400	260–1600	1400–3000	1000–2400	2300	70–2300	15–730	40–1200		600–900
Hardness	Shore D	55–65	55–60	55–64	63–75	75–78	49–55	58–65	72–81	70	72	72	85	55–65	90	40–75	25–72	35–80	8–62	5–40
Density	g/cm^3	2,17	2,15	2,15	1,7	1,8	0,91–0,94	0,94–0,96	0,90–0,91	1,03–1,17	1,0–1,05	1,0–1,17	1,3–1,4	1,2–1,3	1,20	1,05–1,20	0,96–1,10	1,12–1,27	0,89–1,04	0,85–0,98
Coefficient of friction		0,10	0,25	0,21	0,23	0,30	0,60	0,28	0,30	0,40	0,35	0,40	0,35	0,35	0,30	0,22/0,5	0,55	0,2–0,8		
Transparency	See note	***	****	*****	***	*	****	***	***	**	***	***	*	*****	*****	****	****	**	****	****
Melting point	°C	330	257–275	300–310	270	175	110	125	134–165	220	175–190	170–185	160–175	230–250	240	170–240	135–275	160–215		125–165
Min/max service temp.	°C	–240 +260	–200 +200	–200 +260	–190 +150	–60 +150	–30 +80	–20 +100	–10 +120	–40 +150	–50 +100	–50 +100	–40 +100	–40 +140	–40 +120	–50 +80	–40 +130	–40 +130	–50 +125	–40 +115
Water absorption	%	<0,01	<0,01	<0,03	0,02	0,04	0,01	0,01	0,01	1–10	0,2–2,0	0,2–1,6	0,2–1	0,1–0,5	0,3	0,1–0,4	0,9–1,2	0,6–2,5		
Chemical resistance	See note	*****	****	*****	****	****	***	***	****	**	**	**	***	****	*	***	***	***	****	****
Sterilisation	ETO	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sterilisation	Steam	X	X	X	X	X	–	–	X	X	X	X	X	–	–	–	X	X	(X)	X
Sterilisation	Radiation	–	–	–	X	X	X	X	(X)	X	X	X	(X)	X	X	X	X	X	X	–

Notes:
The property data are taken from different sources and are not necessarily typical for any specific grade. This table is unsuitable for specification, since all values are indicative and for guidance only. Optinova Ab takes no responsibility for data given in the table. Excellent: * * * * * Poor: *

OPTINOVA

Optinova, headquartered in Finland, brings you a full service custom extrusion partner. From your first iterations of prototypes, to full product commercialization, Optinova is there for you.

Established in 1971, Optinova has a vast experience in precision extrusion for our costumer designed tubing for the medical device industry. Our capabilities include both fluoropolymer and thermoplastic extrusion.

Our experiences range from research and development to small, medium and automated high volume production. We serve markets in the fields of infusion technology, cardio-, vascular and delivery devices.

Optinova operates under GMP guidelines. Our locations in Finland and Minnesota, USA, are operating under ISO 9001:2008 and ISO 13485:2003 certification.

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