LABTEX®
White Paper

A Complete Guide to High Performance Fluoroplastic Labware

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Materials

Fluoroplastics belong to the 'family' of thermoplastics. The higher the fluoric content, the better the thermal and chemical capacity of fluoropolymers.

Unique properties include:

- Universal chemical resistance
- High thermal load capacity (-300°C to +260°C)
- Resistance to all sterilisation temperatures
- Non flammable
- Resistant to environmental changes (weather, light)
- Non adhesive
- Ultra low friction coefficient
- Unbreakable
- Physiologically safe
- Inert, no taste, odourless
- UV - resistant

Flouroplastics

Polytetrafluoroethylene (PTFE)

PTFE was discovered in 1938 by research-chemists of Du Pont (USA). It is a partly crystalline fluoroplastic and belongs to the thermoplastic group. The rare combination of its exceptional properties is essentially due to its molecular structure. PTFE has a thermal resistance of -260°C to +300°C (there is for example no brittleness of boiling helium at -269°C). This temperature range is reached by no other commercial plastic material. However, the permanent temperature resistance depends on the load. This means that PTFE can be used from -200°C to +260°C at moderate mechanical load. Labware made of PTFE has a white appearance; its surface is non-adhesive and has excellent slip characteristics. The fabrication of PTFE laboratory devices is done by means of isostatic pressing processes or they are machined of extruded semi-finished PTFE material.

PTFE-TFM

PTFE-TFM is a further development of the classic polytetrafluoroethylene (PTFE). The unique properties of PTFE are improved in this second generation. The PTFE-TFM material is characterised by a tighter arrangement of polymers and a lower gas permeability. Additionally, it has an extremely smooth surface and a very low concentration of pores which prevents contamination and makes cleaning easier. The substantially low deformation at load is especially effective at higher temperatures. It is used whenever there is a higher demand for safety and reliability, i. e. in digestion vessels or gaskets.

Tetrafluoroethylene-Perfluoropropylene (FEP)

FEP, a molten copolymer of tetrafluoroethylene and perfluoropropylene with a high-molecular, partly crystalline structure, was introduced on the market in 1960. Its mechanical properties and chemical resistance (max. +205°C) are comparable with those of PTFE, however, the upper limit of the permanent working temperature is lower than that of PTFE. FEP is a typical thermoplastic material which can be treated and machined in the usual way using established methods, although its high viscosity limits the speed of operation. Labware made of FEP is translucent to transparent and non-porous.

Perfluoroalkoxy (PFA)

PFA also belongs to the group of molten copolymers with a high-molecular, partly crystalline structure. Compared with PTFE it has additional side chains consisting of perfluorated alkoxy groups. The properties (chemical and thermal resistance) of this thermoplastic fluoropolymer can be compared with those of PTFE. Labware made of PFA is translucent to transparent, non-porous and particularly useful in high-purity work.

Polychlorotrifluoroethylene (PCTFE)

PCTFE is a partly crystalline polymer, however, compared with PTFE it has only 3 "F" atoms and 1 "CL" atom. This fluoroplastic is harder than all the other materials of this kind and is particularly characterised by its high deformation resistance. PCTFE is resistant to UV radiation and has the lowest gas permeability rate. Labware made of PCTFE is translucent and non-porous. PCTFE is comparable with PTFE – however, with a restricted thermal resistance.

Ethylene-Tetrafluoroethylene (ETFE)

ETFE is a modified copolymer of ethylene-tetrafluoroethylene. Compared with the homopolymer PTFE which can be treated only by means of pressing or sintering, the modified copolymer ETFE can be processed as a thermoplastic. This means that this plastic can be injection moulded by means of the appropriate machines. In the laboratories this material is mainly used as items reinforced with glassfibres, i. e. in screw caps or screw joints.

Polyvinylidene Fluoride (PVDF)

PVDF is a fluoroplastic material that can be machined or processed as a thermoplastic. It is characterised by a good to excellent chemical resistance. Compared with PTFE, PVDF is much harder and more rigid. Its functional temperature range, however, is lower than that of the 'related' PTFE. Compared with other fluoroplastics, PVDF displays a series of unique properties, such as its easy processing, high mechanical values and low specific weight. It is used in many applications.

Polyvinyle Fluoride (PVF)

Compared with the regular polymers, PVF, containing fluorine, displays a stronger chemical linkage and thus, a better inherent stability. PVF displays unique properties when used at temperatures ranging from –70°C to +110°C. It even withstands temperatures of approx. +200°C.

Polyvinyle fluoride does not contain a softener. It is resistant to fading and can easily be cleaned due to its dirt-repelling surface. In particular, foils, films and bags for the gas analysis are made of PVF.

Technical plastics

Polyphenylsiloxan (PPS)

PPS is a new material with a high efficiency. This macromolecule consists of phenylene rings and 1 "S" atom. Therefore it is characterised by a good chemical resistance even at high working temperatures. PPS is particularly suitable for the production of moulded pieces which are subject to high mechanical and thermal stresses. Injection moulding is the most common processing technology for this material. In addition, component parts can be made of semifinished goods by means of cutting. In particular, glass-fibre reinforced compounds are characterised by better rigidity as well as higher dimensional stability under heat than compounds that are not reinforced.

Polyetheretherketone (PEEK)

PEEK is a partly crystalline thermoplastic which withstands high temperatures. Due to its unique properties this material is mainly used in components that are subject to high mechanical stresses. The high upper working temperature (+250°C), the good chemical stability and resistance to hydrolysis as well as the high mechanical values of this thermoplastic will allow PEEK to become the material of the future. In laboratories, PEEK components are mainly used as HPLC fittings, screw joints or as tubing. Its original colour is natural (brown) and its price is considerably higher than that of PTFE or PFA.

Polypropylene (PP)

PP is a polymer of ethylene with an isotactic arrangement of methyl groups. It does not belong to the fluoroplastic group. This material can be autoclaved (at +121°C) and is distinguished by good mechanical properties and good chemical resistance almost to its softening point. Labware made of PP is unbreakable and an economical plastic alternative, however, with restricted chemical and thermal resistance.

Polyamides (PA)

Polyamides are either condensation polymers obtained from diamine and dicarboxylic acid, e.g adipic acid and hexamethylene-diamine or condensation polymers obtained from amino acids respectively from their lactams, e.g. caproic lactam. In general, polyamides are defined according to the number of "C" atoms of their monomers, e.g. PA 6 = polycaproic lactam to PA 12 = polylauric lactam. PA 6 is the most commonly used polyamide. All polyamides are characterised by a high toughness, strength and scuff resistance. The application range for this material ranges from simple turned parts, such as screws or nuts, to plain bearing or toothed wheel work.

Polystyrene (PS)

Polystyrene is a polymerisation product of styrene. Polystyrene is one of the most commonly used plastic materials. For many years it has been processed by injection moulding or by extruding or blowing. Because of its structure, polystyrene is transparent, hard and brittle. A disadvantage is its low thermal and chemical resistance.

Polymethylmethacrylate (PMMA)

PMMA is an acrylic resin based on methyl methacrylate. It is more known under the trade name Plexiglas®. On the one hand PMMA is (approximately 60 times) more elastic than window glass, but on the other hand it is also approximately 10 times more permeable than silicate glass. Of course, the hardness of its surface cannot be compared with that of glass, but compared with all the other materials it can easily be polished to high brilliance. Concerning weight it is much more lightweight than normal window glass.

Elastomers

Acrylonitrile -Butadiene-Caoutchouc (NBR)

NBR is an elastomer on the base of acrylonitrile -butadiene-caoutchouc which is used as a budget priced sealing material (e.g. O-rings for stopcocks). This material has a good resistance in mineral oils and fats and is also resistant to HFA, HFB and HFC-hydraulic fluids. It has a very good elasticity. PERBUNAN® (trade name of company BAYER AG) is not resistant to brake fluids on the base of glycol, HFD liquids, aromatic compounds (e.g. benzole), ester, ketone and amines as well as in concentrated acids and caustic solutions. That is why it is not the ideal material for chemistry.

Fluorcaoutchouc (FPM)

Better known as VITON® (registered trade name of company Du Pont), FPM is an elastomer on the base of fluorocaoutchouc. Many O-rings, lip seals and sleeves are made of FPM. It has a very good resistance to heat, chemicals, weather and ozone. It is also resistant in sulphurated mineral oils and fats, hardly inflammable HFD liquids (basis phosphor ester or chlorinated hydrocarbons). It is not resistant to anhydrous ammonia, caustic soda and potassium, ketones, ether, dioxane and some amines and organic acids. FPM is often used as sealing material (mostly protected from the medium by a PTFE sealing lip).

EPDM

EPDM 3 is an elastomer on the base of ethylene-propylene-diene-caoutchouc which is mostly used for gaskets and O-rings. The main applications are in the area of hot water, steam and lees. It is not resistant to hydraulic liquids on the base of mineral oil but it has a good resistance to weather and ozone. In addition, it is non-ageing. BOHLENDER mainly use O-rings of EPDM for applications where VITON® O-rings are not sufficient.

Perfluoro-Caoutchouc (FFKM)

The perfluoroelastomer FFKM is an elastic sealing material with natural recovery and good accommodation to the sealing surfaces. It has got the same chemical resistance as PTFE. The FFKM O-rings have a very high chemical and thermal resistance. They can be used at long duration conditions with temperatures up to +260 °C. It is known under the trade names KALREZ® of company Du Pont respectively CHEMRAZ® of company Greene Tweed.

Cleaning and Safety in the use of Fluoroplastic Products

General Cleaning

All fluoroplastic materials, PTFE, PFA and FEP, generally have smooth, non-wetting surfaces and can usually be cleaned without problems using only a mildly alkaline detergent. Abrasive scouring agents might damage the surfaces and result in a milkiness of the vessels – especially those made of PFA and FEP. For general cleaning use neutral detergents (pH 7). For a stronger contamination we recommend the use of an alkaline detergent up to pH 12. Never clean or dry vessels in a laboratory washing machine or autoclave if they are sealed.

Cleaning For Trace Analysis

Prior to use for trace analysis, the vessels should first be filled with a 1N HCL and HNO3 solution. This solution should be allowed to stand for a maximum of six hours at room temperature. The vessels should then be rinsed with deionized water. This procedure will minimise the leaching of contaminating anions and cations from the vessels' surface.

Autoclaving at 121°C

Vessels made of PTFE, PFA or FEP can be steam autoclaved at 121°C or dry heat autoclaved at 160°C. All vessels with screw covers or stoppers must be open while being autoclaved. Autoclaving of closed vessels will result in plastic deformation or destruction of the vessels.

Worth Knowing

Plastics in Microwave Ovens

Plastics in general and fluoroplastics with their high thermal resistance in particular are suitable for the microwave energy. They allow a transmission of microwaves and thus a quick heating of the contents of the vessel. Vessels made of fluoroplastics are particularly suitable for a heating of aggressive chemicals, such as acids or solvents. Attention should be paid to the fact that the vapors produced can be sufficiently exhausted and that vessels or containers may be only heated when open e.g. to avoid a possible bursting of the rupture membrane in the digestion vessel.

Pressure Resistance of Bottles

Standard bottles made of PTFE, PFA or FEP should not be pressurised due to their thin walls. Pressurisation could result in permanent deformation. For applications involving pressure digestion vessels and reaction vessels are suitable.

Fluoroplastics – Heating

It is difficult to heat PTFE due to its bad heat transmission and because the maximum surface temperature must not be exceeded.

Heating by a heating mantle with a surface sensor

When heating with a heating manual, a large surface of the vessel is covered. This supports the heat transmission and reduces the heating period. The mantle must have a sensor on its surface. This probe measures the temperature on the surface of the PTFE and switches the mantle off on exceeding 260°C.

Heating by a thermostat

The heat transmission is provided by the bath medium (oils or liquids). Controlled by an adjustable thermostat the temperatures on the surface of the PTFE vessel will not become too high. Depending on the immersion depth, a large surface for good heat transfer is provided. As with mantles though, the heat transfer fluid should not exceed 260°C

It is not recommended to heat PTFE with a naked flame or hotplate. Both these methods create hotspots and harmful decomposition of the product can occur.

Choosing stirrer shafts

The following information is based on experimentation and practical testing. Stirring elements are made for clockwise rotation (when viewed from above).

The shaft diameter depends on the products used as well as their viscosity. The higher the viscosity, the larger the shaft diameter. If in doubt, always choose the largest diameter possible. It is normally possible to reduce the chucking diameter.

Stirrer shafts with a diameter of 8, 10 and 16mm are most commonly used. For standard applications up to a rotation speed of 350rpm and max. length of 600mm, a shaft diameter of 10mm will be sufficient. For stirring of high viscosity products or shafts over 600mm a stirrer shaft of 16mm should be considered.

Propellor stirrer shafts
Stirrer shaft with several inclined, arched or partly twisted blades. The stirring effect is based on a mainly axial flow which moves away from the agitator. Changes in the blade inclination or rotating direction result in a change.

Discoidal stirrer shafts
Stirrer shaft with a blade including several plain or curved paddles. Stirring effect is based on a radial, outwards directed flow with axial suction from the bottom and the top. The dispersing liquid is exposed to high shear.

Impeller stirrer shafts
Stirrer shaft with three angular, arched paddles. The stirring effect is based on a radialflow which is diverted axially depending on the position of the stirrer.

Stirrer shafts with rigid paddle
Stirrer with a narrow blade. The stirring effect is based on a radial and axial flow. The product is exposed to shear forces ranging from moderate to strong.

Stirrer shaft with rigid blade
Stirrer shaft with solid, plain blade. Stirring effect due to different rotation speeds of the product displaced by stirring and the solids content in the vessel.

Stirrer shaft with angular blades
Stirrer shaft with several inclined, rectangular straight blades. The stirring effect is based on an axially directed flow combined with an increased shear rate. Reversal of the flow can be obtained by changing the inclination of the blades or the rotation direction.

U shaped stirrer shafts
Anchor stirrer blade sized according to the diameter of the vessel. The blades should be at least equal to 0.9 x the diameter of the vessel. The stirring effect is based mainly on tangential flow with poor axial forces.

Magnetic stirring and BOLA stirrer bars – what you need to know about magnetic stirring and mixing

Stirrer – magnetic stirring

Magnetic stirring is a widely used method of stirring and mixing in liquid media. This process can be used over a broad temperature range and with virtually any chemical agent, as well as in closed or open systems, under pressure or vacuum.

The basic system consists of two components. A stirrer magnet placed in the liquid and a magnetic drive located outside the vessel.

Both stirrer magnet and magnetic drive form a 'magnetic circuit'. For trouble free stirring in liquids with different viscosities the magnetic drive should have a wide speed range.

The stirrer magnet is a bar magnet encapsulated in a material which protects the magnet and prevents contamination of the liquid medium.

In principle, it is difficult to find the most effective stirring bar for a particular application but important factors are the vessel shape and the viscosity of the stirring medium. For example, in a petri dish a long stirring bar at low speed will be effective. In a round bottom vessel egg-shaped (oval) magnetic stirrers will be a suitable choice. In general definitive advice for or against a certain stirring bar form cannot be given. If in doubt, a test of several different stirring bars may be helpful.

For optimum results, both the drive magnet and stirring bar are important.

For maximum efficiency the distance between the magnetic poles of the drive magnet and the length of the stirring bar should be equal. A magnetic stirring bar which is too small will eventually gravitate toward one of the poles of the drive magnet and will not function.

Stirring efficiency is influenced by the material and thickness of the cover plate of the magnetic stirrer and the thickness of the vessel. Flat bottom vessels eg beakers should be used whenever possible directly on the plate of the stirrer.

Choice of stirring bars

Improperly selected stirring bars will 'jump around' in the vessel and cause ineffective mixing of the product. Here is an overview of the most common magnetic stirring bar types:

Cylindrical magnetic stirring bars – these are the most commonly used magnetic stirring bars. Due to their simple shape they are easy to produce and are offered at low cost. Cylindrical magnetic stirring bars offer excellent centering and smooth running characteristics.

Glass magnetic stirring bars – they have a non-porous and smooth glass coating. Therefore there should be no cross contamination in usage. However, abrasion can occur between glass stirring bars and glass vessels.

Ultra magnetic stirring bars – these magnetic stirring bars have very smooth and seamless surfaces. Therefore there should be no cross contamination in usage. They are mainly used for high purity work or trace analysis.

Power magnetic stirring bars – with a special magnetic material offering higher torque loads than conventional stirring bars. This product is used for agitating viscous liquids or for bridging the gap between the magnetic stirrer and the stirring bar.

Square magnetic stirring bars – are particularly suitable for big vessels due to the high magnetic force. Solids are released or removed from the bottom of the vessel

Egg-shaped magnetic stirring bars – are particularly suitable for round bottom flasks. Their shape follows that of the flask and ensures complete mixing.

Star head magnetic stirring bars – for optimum stirring in tall, narrow diameter vessels. Ideal for cuvettes or test tubes.

Safety Advice

Risks and adversarial effects

Fluoroplastics are inert plastics, in normal use there are no risks to human health or the environment. If the material is exposed to temperatures of more than +350°C, it is possible that hazardous materials such as HF, COF_2, and others are released and can cause bad chemical burns that are not immediately noticeable.

Symptoms after contact

The materials released during thermal decomposition are very dangerous if in contact with eyes, skin or if breathed in.

Eyes: redness, irritation, burning
Skin: redness, irritation, burning
Breathing in: headache, shortness of breath, shivering, fever, raised pulse
Special instructions in case of breathing in: Symptoms may only become apparent after some hours. Seek medical advice.

Contacts

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