

Fluoropolymers Isostatically molded PTFE of highest quality

Fluoropolymers PTFE –the engineering material with potential

Polytetrafluorethylene, PTFE, is a state-of-the-art, high performance plastic, which is used in a broad range of industries. This plastic is also known by trade names such as Teflon™, Dyneon™ or Fluon®.

Berghof produces semifinished products and prefabricated components from this material and its compounds for mechanical engineering, the automotive industry, chemical engineering, semiconductor and high voltage technology and for applications in the optical sector.

Convincing properties

The special technical properties of PTFE plastic are crucial for its success.

PTFE characteristics

- Broad temperature range from -200 °C to +260 °C
- Universal resistance to chemicals, even against aggressive acids such as aqua regia
- Excellent dielectric properties
- A high degree of hydrophobicity
- Extremely non-adhesive
- Low refractive index at ~1.38
- Physiologically harmless
- Excellent for mechanical processing

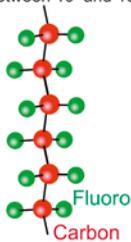
TFM™ PTFE a second-generation PTFE

Dyneon the manufacturer is offering a so-called second-generation PTFE under the brand name TFM™ PTFE. At Dyneon small quantities of a modifier have been built-into the linear chain of the polymer. This modified variant is processed with conventional PTFE, but shows a significantly improved properties profile. The resistance to chemicals, thermal stability and the broad range of temperatures at which it can be used are

comparable to that of Standard PTFE. However, the modified PTFE possesses a significantly reduced melting viscosity, a considerably reduced microporosity and a lower Stretch-Void-Index (SVI). The outcome is non-porous components with a low degree of permeability. The permeation rate of gases is significantly lower than for unmodified PTFE and is only a little above the PFA. Modification results in further positive properties. For example, the capacity for welding and the quality of the surface are much improved compared to conventional PTFE.

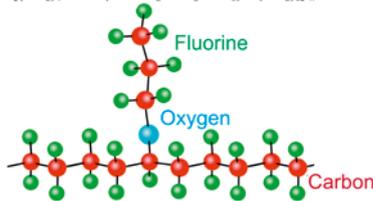
PTFE structure

Polytetrafluoroethylene (PTFE) is a linear polymer with the formula: $-(CF_2 - CF_2)_n$, and a molecular weight between 10^5 and 10^7



Modified TFM™ PTFE

Polytetrafluoroethylene (PTFE) is a branched polymer with the formula: $-[(CF_2)_4 - CF(-O-CF_2-CF_2-CF_3) - (CF_2)_3]_n-$



PTFE und modifiziertes PTFE (TFM™-PTFE)

Processing competence

We at Berghof process both base materials, PTFE and TFM™PTFE, including their compounds, to produce numerous semi-finished products and prefabricated components. Besides the conventional production and processing techniques, we also have special knowledge and skills in isostatic compression molding and in the manufacture of porous PTFE. Semi-finished PTFE products are manufactured by means of extrusion or by compression-molding. In compression-molding as a rule two different techniques are applied. In single-axis compression molding the PTFE powder is compressed in one direction; in isostatic compression molding it is compressed evenly from all sides.

Processing of PTFE and TFM™PTFE by compression molding takes place in the process steps: compress.- sinter - cool down. Processing has a significant effect on molecular weight, crystallinity and pore content of the molded components and hence also their quality. Compression molding becomes of central importance as the first step of the process. Faults that occur here cannot be put right in the subsequent steps of the

process. To obtain optimal compression and therefore the optimal material properties, we have decided on the isostatic compression molding method; a method, which Berghof already developed over 40 years ago.



PTFE before sinter process

Isostatic compression-molding permits components to be manufactured in a sophisticated, geometric shape, which is unattainable with the conventional methods.

There is one variant of isostatic compression molding, which we use to manufacture high-purity vessels, such as those required in trace analysis. Here the TFM™PTFE powder is pressed onto an appropriate plastic mandrel. This method dispenses with the final mechanical reworking of the vessels, and contamination of the vessels from the abrasion of the metal-working tools.

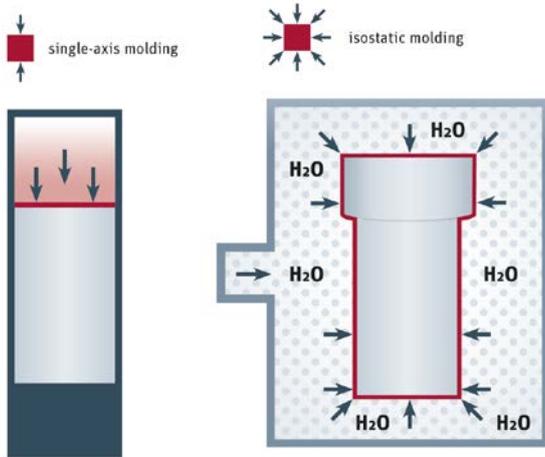
Isostatic compression molding

When conventional, single-axis compression molding methods are applied, as a rule the material is compressed vertically in a mold with a force plug. There is no horizontal compression crosswise to the compression direction.

By contrast, in the isostatic compression-molding process the force is applied to the material evenly and simultaneously from all directions in space via a hydraulic medium and compresses it homogeneously. Hence optimal compression is achieved, resulting in minimal porosity, a better surface structure and maximum tensile and compressive strength. No preferred directions are created and isotropic material properties are retained. Particularly the tensile and compressive strength of the material is consistent in all directions in space.

In practice a rubber mold filled with PTFE- or TFM™PTFE powder and then sealed watertight is conveyed into the pressure vessel of a compression-molding plant. The pressure exerted on all sides of the rubber mold via the fluid in the pressure vessel compresses the sealed-in PTFE powder evenly. After being compression-molded, the PTFE compression-molded part is removed from the rubber mold and subjected to a sintering cycle in the furnace.

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Comparison of molding technologies

Quality advantages thanks to isostatic compression molding

The advantages of isostatic compression molding can be illustrated by means of appropriately enlarged REM images. When magnified 100 times the granulate particles of the original material can still be identified in PTFE if it has been subjected to single-axis compression molding. By contrast, isostatically compression-molded PTFE shows a significantly more consistent surface structure. It is roughly equivalent to single-axis compression-molded TFM™PTFE. However isostatically compression-molded TFM™PTFE achieves a much finer and smoother structure. Furthermore, when magnified 2,500 times, in single-axis compression-molded material flaws become visible, which no longer occur in isostatically compression-molded TFM™PTFE.

Comparison of PTFE vs TFM™-PTFE				
Material	PTFE		TFM™-PTFE	
	Single axis	Isostatic	Single axis	Isostatic
Compression-molding technique				
Density (g/cm³)		2.15	2.16	2.16
Tensile strength (N/mm²)	38.9	41.3	44.0	45.1
Elongation at rupture	289	333	484	489
REM image 100-fold magnification				
REM image 2500-fold magnification				

Comparison of PTFE and TFM™-PTFE

Application competence

Our core competences are products for laboratory technology and semi-finished products and prefabricated components made from porous PTFE.

53-0129-97-01-00-005, PTFE-CompressionTechnology_PI_en_080616, Änderungen und Irrtümer vorbehalten, Printed in Germany

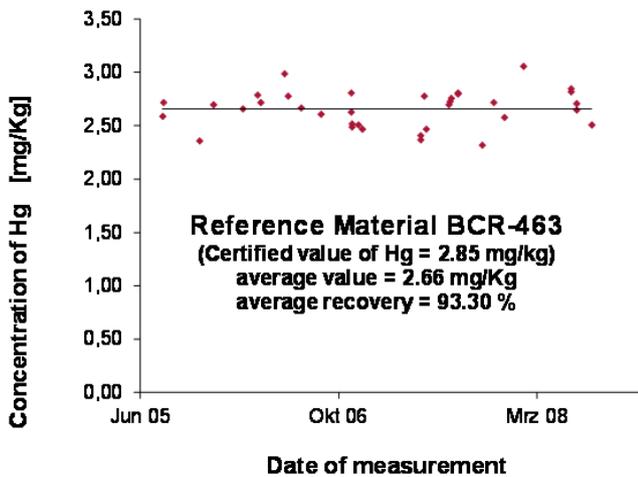
For laboratory technology we produce high-pressure reactors with PTFE liners for synthesis reactions and pressure vessels in pure TFM™PTFE for preparing samples in analytic chemistry by means of microwave pressure digestion

Pressure vessels made from fluoropolymers:

A special core competence of Berghof is the manufacture of pressure vessels from or in combination with fluoropolymers. Isostatic compression-molding is the fundamental prerequisite to be able to produce pressure vessels from high-purity TFM™PTFE without a supportive shell. The vessels manufactured according to this method are distinguished by the high purity of the materials and an at least 3-year service life.

Blank values of Berghof digestion vessel (Blank digestion with 10mL HNO₃, 200°C, 15 min)

Element	Concentration [µg/L] (ppb)
Ag	<0.025
Al	<0.1
As	<0.025
Ba	<0.05
Be	<0.25
Bi	<0.025
Ca	<0.2
Cd	<0.025
Co	<0.025
Cr	<0.05
Cu	<0.025
Hg	<0.25
Fe	<0.1
K	<0.5
Li	<0.025
Mg	<0.1
Mn	<0.05
Na	<0.1
Ni	<0.025
Pb	<0.05
Sr	<0.025
U	<0.001
V	<0.025
Zn	<0.1



Mercury analytics in Tuna fish after digestion in Berghof digestion vessel

In the porous PTFE sector we produce semi-finished products and complex prefabricated components. By optimising the base materials we can significantly expand the range of applications and the performance of porous PTFE. We have configured specific new properties for the purposes of special applications:

- Variable pore sizes and pore volumes within narrow tolerance limits
- An excellent combination of breathability and water retention capacity
- To achieve consistent volumetric flow rates in graded throughputs
- High degree of optical reflection at >98%
- Wide usable spectral range from 250 nm to 2,500 nm
- Homogeneous, diffuse surface reflection
- Create defined reflection rates by the varying the grey colouring of the base material.



Pressure digestion vessels made of TFM™-PTFE

Example applications

Semiconductor, chemical, sensor and analytic technology:

- Round and rectangular vessels, heating coils and pipes must be sheathed for etching processes
- Pressure digestion vessels
- Corrosion protection liners for reactors
- Liners on pumps and valves
- Hollow bodies, such as bottles, round pistons, floats etc.
- T-pieces and pipe bends for piping systems to accommodate aggressive media
- Thin-walled pipes and pipes with large cross-section modifications
- Filtering of gases and fluids
- Catalyst substrate
- Protective sheaths for sensors
- Diaphragms
- Gas injection and/or gas distribution (perlatators)

Automotive technology:

- Water-repellent gas/pressure compensation element for protecting electronic control systems from pressure build-up and water ingress; typical examples:
- Headlights
- Horns (hooter)
- ABS (Antilock Braking System)
- Injection control
- ASR (Anti Slip Regulation)
- Airbag
- Automatic controls

Optical measurement and applications technology:

- Reflection standards
- Interior coating of Ulbricht integrating spheres
- Diffuse reflectors
- Projections screens
- Display backdrops
- Reflectors for highly intensive radiation sources



Various application for PTFE