## GENERAL

Polytetrafluoroethylene (PTFE-Teflon®, Dyneon®, Diakin®) is the most important member of a group of fluoropolymers with a range of unique and useful properties not possessed by any other polymeric material.

The unique properties of PTFE include –

- Almost totally chemically inert
- Exceptional thermal stability
- Electrical and dielectric properties
- Non-stick properties
- Flexural strength

This range of properties means that the scope for the use of PTFE products is potentially very high, however, because of cost considerations and difficulties of fabrication PTFE is generally considered a specialist material for use in highly specific and demanding applications.

## STRUCTURE

PTFE is a linear chain polymer of tetrafluoroethylene [TFE] with the repeat structure $[-CF_2-]_n$. The molecular weight of the polymer is very high and this coupled with the protective shield of fluorine atoms around the carbon core provides the basis for the unique properties of PTFE.

## RELATED FLUOROPOLYMERS

- **Modified PTFE** (Dyneon® TFM, Teflon® NXT) **–** A co-polymer of PTFE where a small amount (less than 1%) of a co-monomer such as perfluoropropylvinyl ether is incorporated in the PTFE chain. Properties of the material are similar to PTFE but with improved mechanical properties, reduced porosity and can be self fused.
- **PFA –** A copolymer of TFE and a per-fluoroalkyl ether. PFA has many of the desirable properties of PTFE and is translucent and melt processable. Maximum working temperature is 260°C.
- **FEP –** A copolymer of TFE and hexylfluoropropylene. Exhibits many of the desirable properties of PTFE. High clarity and melt processable. Maximum working temperature 200°C.

## CHEMICAL RESISTANCE

Over its operating temperature range the chemical inertness of PTFE is generally considered to be total.

Rare examples of known reactions of PTFE are –

- Slight reversible swelling of PTFE with some fluorinated hydrocarbons, benzyl chloride, dimethylformamide and chloroethanes. At higher temperatures these substances may cause mechanical breakdown by diffusing into the polymer and expanding the structure.
- Molten or dissolved alkali metals, such as sodium in liquid ammonia and sodium in a naphthalene-tetrahydrofuran mixture, will abstract fluorine from the surface of the polymer to leave a black finish (believed to be carbon).
- Reactions with alkali earth, alkali metal oxides and carbonates at temperatures above 350°C have been noted.
- Reactions with fluorine, some fluorine related compounds and chlorine trifluoride have been observed at elevated temperatures and pressures.
- Gases including oxygen, helium and halogens, notably chlorine and bromine, have been reported as reversibly diffusing into PTFE without apparent chemical reaction.
- A vigorous reaction when mixed with finely powdered aluminium and heated.

**PTFE – The material of choice when chemical resistance is essential.**

## PURITY

Virgin, unfilled, PTFE materials are considered to have very high levels of purity.

Typical values –

| | PTFE | TFM |
|---|---|---|
| | Ng/cm$^2$ | Ng/cm$^2$ |
| Al | 3.7 | 2.2 |
| Ca | 22 | 11 |
| Cu | 21 | 24 |
| Fe | 5 | 3 |
| Pb | 3 | 2 |
| (Extraction medium 2% Nitric Acid for 2 days at 20°C. Origin – Dyneon®) | | |

Virgin PTFE and TFM can, therefore, be used in applications where very high levels of purity are required, eg, in trace analysis and semiconductor manufacture.

- **Filled PTFE -** PTFE is available with a range of fillers such as glass fibre and carbon which are used to improve certain properties of PTFE. Filled PTFE does not have the same levels of purity as virgin material.
- **Re-Processed PTFE -** Consists of virgin PTFE blended with a very fine powder of ground PTFE scrap and is used to reduce cost. Re-processed PTFE does not have the same levels of purity as virgin material.
- **Paste Extruded PTFE -** PTFE processed by paste extrusion may contain residues arising from the lubricant used in the extrusion process.
- **PFA -** has a more homogeneous structure than PTFE, can exhibit a better extractable performance than PTFE, however, this may be offset by the possibility of metal contamination arising from the moulding tools used to process PFA.
- **FEP -** similar purity properties to PFA.

## SOLUBILITY

PTFE is generally regarded as being completely insoluble in all media except under very extreme conditions of temperature and pressure.

Contamination due to dissolution will not be an issue when using PTFE.

Exceptions include –

- Dissolution of PTFE has been reported in materials such as cyclic polyfluorocarbon oligomers at 300°C at atmospheric pressure.
- Under suitable conditions of temperature and pressure dissolution of PTFE has been observed in some perfluorocarbons, perfluorocarbon ethers, sulphur hexafluoride and carbon dioxide. Dissolution of PTFE in these types of solvent, followed by precipitation of the substrate has been used to prepare specialised forms of PTFE.
- Swelling of PTFE has been reported with benzyl chloride but without chemical reaction.

**PTFE – NO Dissolution.....NO Contamination**



For further technical information and support on PTFE and it's applications, please contact us at enquiries@cowie.com.