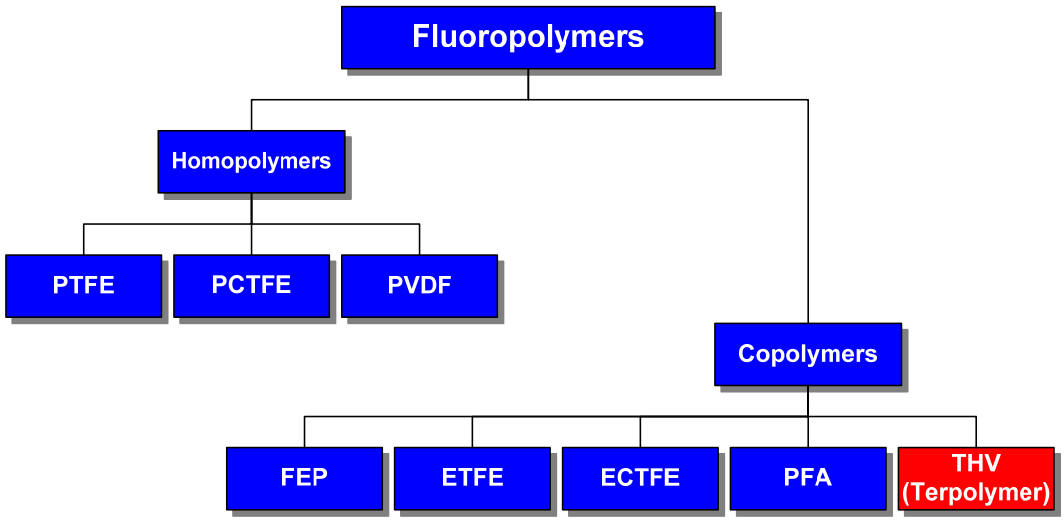
ZEUS®

TECHNICAL NEWSLETTER

Introduction to THV

Introduction

This month the focus is on another melt-processable member of the fluoropolymer family, THV (tetrafluoroethylene, hexafluoropropylene, vinylidene fluoride terpolymer). THV fits into the broader family of fluoropolymers as shown below:



THV in the fluoropolymer family

THV consists of three different polymer monomers (**T**etrafluoroethylene, **H**exafluoropropylene and **V**inylidene fluoride or **T**, **H** and **V** respectively) joined together in the following form:

— T — H — V — T — H — V — T — H —

This long chain makes up the basic structure of the THV molecule and gives it its unique properties.
The main current supplier of THV is 3M, who produce a range of THV materials under the brand name of Dyneon™. THV was first produced by 3M and is melt-processable by most plastics processing methods such as injection molding, extrusion, and film blowing.

Properties

The general properties of THV are typical of many other fluoroplastics. They include:

- Melt processable at low temperatures.

- Exceptional optical clarity and transmittance across the UV and visible light spectrums; THV is one of the most optically clear of the fluoroplastics and is now used in many glazing applications.
- THV is the most flexible of the fluoroplastics with exceptional flex life.
- Good bondability to many common elastomers and plastics; can easily be welded to itself.
- Excellent permeation resistance to hydrocarbon fuels, most gases and other aggressive chemicals.
- Chemically inert and resistant to all common solvents.
- Available in high purity FDA compliant grades for repeated food use.
- Available in ultra-low extractables grades for use in critical fluids handling.
- Available in flame resistant grades to meet UL 94 VO.

Physical and Mechanical

As a terpolymer, it is possible to vary the monomer composition of THV and affect its physical and mechanical properties. Typical mechanical and thermal properties are displayed below:

Property	Approximate Value
Tensile Strength at Break (at 23^{o}C)	**20 - 28 MPa**
Flexural Modulus (at 23^{o}C)	**80 - 490 MPa**
Elongation at Break (at 23^{o}C)	**500 - 600%**
Izod Notched Impact Strength (at 23^{o}C)	**No Break**
Low Temperature Toughness	**$^{-}$50^{o}C**
Maximum Service Temperature	**150^{o}C**
Long Term Service Temperature	**80 – 120^{o}C**
Melting point	**120 to 165^{o}C**
Specific Gravity	**1.78 – 1.97**
Water Absorption	**Less than 0.01% (50% rh)**
Transparency	**Exceptionally transparent**

Please note that resin grades may affect these values.

Thermal and Fire

THV has no difficulty in achieving UL 94 VO for flame resistance. The Limiting Oxygen Index (LIO) for THV is greater than 65, which means that there must be over 65% oxygen present to support free combustion. Air contains approximately 21% oxygen. Therefore a material with an LOI greater than 21 will probably not support burning in an open-air situation.

Chemical Resistance

Although slightly less resistant than fully fluorinated polymers such as PTFE and FEP, THV has excellent chemical resistance against many common solvents. Solvent soluble grades for coating applications are soluble in ketones, esters, and ethers for solution preparation.

Specific grades of THV are suitable for food contact and are FDA compliant (FDA 21.CFR.177.2660 – rubber articles for repeated use).

Optical

THV has an extremely high transparency and low haze with good transmittance in both the UV and visible wavelengths. The optical properties of THV make it suitable for use in applications where a glass-clear polymer with good high or low temperature performance is required.

THV can be almost any color and the low processing temperatures can utilize both organic and inorganic pigments.

Advantages and Limitations

Advantages	Limitations
1. Melt-processable fluoropolymer and processing can be carried out at temperatures similar to those of conventional thermoplastics.	**1. High cost in relation to many other polymers.**
2. Exceptional flexibility at low temperatures.	**2. Reduced chemical and dielectric properties in comparison to PTFE.**
3. Exceptional clarity and transparency with good transmittance of both UV and visible wavelengths.	

Processing

As a melt-processable fluoropolymer, THV can be processed by most of the traditional plastics processing methods. The material is used extensively for injection molding, extrusion (from profiles to wire coating), blow molding, and cast films.

THV can be injection molded at far lower temperatures than most other fluoropolymers, typically from 200 to 280^{o}C and, as a result, it does not always need the same degree of corrosion resistant processing equipment required for other fluoropolymers. Despite this, THV is a fluoropolymer and must be treated as such during processing. For example, thermal degradation can occur if the material is left at high temperatures (>250^{o}C) for extended periods.

The low processing temperatures mean that THV can be processed using conventional plastics processing machinery.

Processing Method	Applicable
Injection molding	**Yes**
Extrusion (profiles, films, sheet, tubing, and cable or wire coating)	**Yes**
Blow molding	**Yes**
Cast films	**Yes**
Film laminating	**Yes**

THV Grades

THV is produced in a variety of grades depending on the processing method. Specific grades are available for injection molding, extrusion, and blow molding. A soluble grade is also available for coating applications.

Typical Applications

The unique properties of THV have created new applications for fluoropolymers particularly in the production of multi-layer hoses, tubing, as well as extremely optically clear film and sheet.
Typical applications are:

- Barrier layers in automotive fuel systems products: the adhesion between THV and elastomers allows composite barrier layer constructions such as NBR-THV-NBR (nitrile rubber/THV/nitrile rubber tube) and ECO/THV (inner layer of THV with outer layer of epichlorohydrin rubber). Effective barrier layers prevent fuel from being leaked into the atmosphere.
- Architectural and protective coatings: THV has been used as an interlayer material in the construction of safety glass. The interlayer must be optically clear and at the same time hold the glass together safely in the event of breakage. The high temperature and heat resistant properties of THV also allow the production of safety glass with a one-hour fire rating.
- Glazing: THV is used for viewing windows in tents in arctic conditions. The windows' flexibility is often maintained.
- Chemical processing industries
- Semiconductor industries
- Solar energy
- Polymer optical fibers
- Pneumatic lines
- Retractable coils for wet bench spray guns
- Fiber optics

Summary

THV is the most flexible of all the fluoropolymers. This flexibility, combined with superior optical clarity and excellent permeation resistance, makes THV uniquely suited for demanding applications when a melt-processable fluoropolymer is needed.

Zeus is able to process THV for use in a number of different products including fluoropolymer tubing, lay-flat tubing, special profiles, monofilament, and multi-lumen tubing. All of these products can be produced to tight tolerances and can be modified by the inclusion of additives such as bismuth (for radio-opaque tubing), glass (for increased heat deflection temperature and tensile strength), carbon, pigments and other special additives.