INOFLON®
Modified PTFE Resins
Engineered for Robust Applications
INOFLON® Modified PTFE resins are engineered for use in critical applications which are beyond the scope of Virgin PTFE.

During sintering of molded parts, the particle fusion of Virgin PTFE is hindered due to the high viscosity of the Virgin PTFE melt. As a result, there is a slow rate of void closure and a small fraction of void volume remains in parts made from Virgin PTFE. Presence of micro voids leads to following limitations:

1. Increased permeation in parts
2. Reduction in the mechanical properties such as flex life and stress crack resistance

In order to reduce the viscosity and overcome the limitations, Modified PTFE shows significantly reduced molecular weight. As a consequence, melt viscosity is reduced and particle fusion takes place appropriately. In order to keep the physical properties of low molecular weight PTFE on the same level as regular PTFE, the addition of a co-monomer is required to disturb the enhanced crystalization behavior of this kind of PTFE significantly. As a result, in INOFLON® Modified PTFE the benefits of reduced molecular weight are combined with excellent mechanical properties.

- Reduced permeability
- Reduced deformation under load
- Better flexural fatigue resistance
- Smooth surface
- Higher transparency
- Weldability
- Higher dielectric strength
- Reduced stretch void index
GFL has developed two Modified product lines to meet specific needs of particular processes and applications:

1. M690/ M290 product line especially for big billet manufacturing and for applications requiring higher flex fatigue
2. M695/ M295 product line for superior barrier properties, lower cold flow and excellent weldability
Enhanced Properties in INOFLON® Modified PTFE

In addition to the properties of conventional PTFE, INOFLON® Modified PTFE resins also exhibit certain enhanced properties such as:

1. **Lower permeation due to reduction in the level of micro voids (Improved coalescence of particles during sintering)**

![Helium Transmission Rate Graph](image)

**Test conditions**
- **Thickness:** 1.00 mm
- **Temperature:** 23°C
- **Relative humidity:** 0%
- **Test method:** ISO 15105-1

Lower permeation makes INOFLON® Modified PTFE the 'material of choice' especially for chemical, semiconductor and other industries handling corrosive chemicals or gases.

**Applications include**
- Lining for pipes, vessels, ducts and reactors
- Seats for valves and gaskets
- Heat exchangers and other Flue-gas desulphurization (FGD) equipment used in the power generation industry etc.
- Full Modified PTFE constructions such as pumps and valves for production, storage, transportation and usage of high purity semi-conductor chemicals
2. **Less deformation under load due to superior distribution of crystallites in amorphous Modified PTFE matrix**

![Deformation Under Load](chart)

The values of deformation under load for INOFLON® Modified product lines may differ slightly, however, both exhibit lower deformation under load when compared to Virgin PTFE. This makes INOFLON® Modified PTFE the ‘material of choice’ for automotive, mechanical, food, pharmaceutical and bio-technology industries.

**Applications include**

- Seals, gaskets and especially components where resistance against high compressive strength is required and addition of fillers is not advisable

3. **Better flexural fatigue resistance**

Compared to INOFLON® M695 and INOFLON® M295, molecular weight of INOFLON® M690 and INOFLON® M290 is higher. Due to higher barrier properties of Modified PTFE compared to conventional PTFE, less chemicals penetrate into the polymer matrix when exposed to harsh medium. As a conclusion, M690 performs best in applications with higher fatigue requirements when exposed to aggressive chemicals.

<table>
<thead>
<tr>
<th>MIT Flex Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Sample</td>
</tr>
<tr>
<td>INOFLON® M690</td>
</tr>
<tr>
<td>INOFLON® M695</td>
</tr>
</tbody>
</table>

Test Method: ASTM D 2176

Better flexural fatigue resistance in parts made of Modified PTFE makes it a ‘material of choice’ for semiconductor, paint, food and chemical industries.

**Applications include**

- Diaphragms in pumps and valves
- Bellows etc.
4. Smooth surface because of improved tensile and elongation properties

Surface of components made from INOFLO® Modified PTFE is smoother when compared with Virgin PTFE, hence making it a ‘material of choice’ in the semi-conductor and electrical industries.

Applications include

- Electrical insulation films in Printed Circuit Boards (PCB) and capacitors
- Parts with smoother surface when applied in food industry, give easy-to-clean properties and improve Sterilisation in Place (SIP) and Cleaning in Place (CIP) capabilities etc.

Smooth surface parts are used in high purity chemicals due to their lower specific surface area, which leads to lesser leaching which further contributes to lower contamination from surface.

5. Higher transparency

INOFLON® Modified PTFE resins have better transparency than conventional PTFE making it a ‘material of choice’ for chemical bags, tubes and pipes used for visual inspection in chemical, food and pharmaceutical industries.

6. Weldability due to the reduced molecular weight

Contrary to conventional PTFE, Modified PTFE is weldable.

In order to achieve the best weldable properties in Modified PTFE, special techniques are required. Properly welded parts do not show any disadvantages when compared with unwelded parts.

Weldability makes Modified PTFE the ‘material of choice’ in semi-conductor, chemical, paint and mechanical industries.

Applications include

- Bags for high purity chemicals
- Wafer carriers
- Dip pipes and gas distributors in chemical reactors
- Gaskets for chlorine electrolysis cells
- Ultrasonic level sensors etc.
7. Higher dielectric strength due to fewer pores in parts made from Modified PTFE

**Applications include**

- Thin films in Printed Circuit Boards (PCB) and capacitors
- Skived film for wrapping tapes around wire and cable insulation
- Connectors and spacers in connectors

8. Reduced Stretched Void Index (SVI)

SVI describes the tendency of the void formation of the material during stretching. Index is determined using the following formula...

\[
SVI = \left(\frac{USG}{USG} - \frac{SSG}{SSG}\right) \times 1000
\]

USG – Un-stretched Specific Gravity
SSG – Stretched Specific Gravity

Due to lower SVI, films of INOFLO® Modified PTFE can be stretched into thinner transparent films without compromising on Break Down Voltage (BDV). This makes it a ‘material of choice’ in chemical and food industries.

**Applications include**

- Parts made by deep drawing or blow molding such as diaphragms, protective covers or containers for chemicals
INOFLON® Granular Virgin PTFE Vs. INOFLON® Granular Modified PTFE

<table>
<thead>
<tr>
<th>Properties</th>
<th>Test Method</th>
<th>Unit</th>
<th>INOFLON® PTFE (640)</th>
<th>INOFLON® Modified PTFE (M690)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size ($d_{50}$)</td>
<td>ASTM D 4894</td>
<td>µm</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Bulk Density</td>
<td>ASTM D 4894</td>
<td>g/l</td>
<td>400</td>
<td>350</td>
</tr>
<tr>
<td>Std. Specific Gravity</td>
<td>ASTM D 4894</td>
<td>-</td>
<td>2.16</td>
<td>2.16</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D 4894</td>
<td>MPa</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Elongation</td>
<td>ASTM D 4894</td>
<td>%</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Mold Shrinkage</td>
<td>ASTM D 4894</td>
<td>%</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Permanent Deformation Under Load (14 MPa)</td>
<td>ASTM D 621</td>
<td>%</td>
<td>11.2</td>
<td>4.6</td>
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<tr>
<td>Void Content</td>
<td>Internal</td>
<td>%</td>
<td>0.95</td>
<td>0.39</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>ASTM D 149</td>
<td>kV/mm</td>
<td>85</td>
<td>90</td>
</tr>
</tbody>
</table>

INOFLON® Granular Modified PTFE

GFL offers the following range of INOFLON® Modified PTFE resins:
- **Fine Cut** – INOFLON® M690, INOFLON® M695
- **Free Flow** – INOFLON® M290, INOFLON® M295

<table>
<thead>
<tr>
<th>Grade</th>
<th>Preferred Processing Technique</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>INOFLON® M690</td>
<td>Compression Molding</td>
<td>Thin films &amp; compounding. Machined parts with minimal thickness of 30 µm</td>
</tr>
<tr>
<td>INOFLON® M695</td>
<td>Compression Molding</td>
<td>Thin films &amp; compounding. Machined parts with minimal thickness of 30 µm</td>
</tr>
<tr>
<td>INOFLON® M290</td>
<td>Automatic Molding, Isostatic Molding, Ram Extrusion Molding and Compression Molding</td>
<td>All applications &amp; machined parts with minimal thickness of 500 µm</td>
</tr>
<tr>
<td>INOFLON® M295</td>
<td>Automatic Molding, Isostatic Molding, Ram Extrusion Molding and Compression Molding</td>
<td>All applications &amp; machined parts with minimal thickness of 500 µm</td>
</tr>
</tbody>
</table>
**Typical Properties**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Test Method</th>
<th>Units</th>
<th>INOFLO® M690</th>
<th>INOFLO® M695</th>
<th>INOFLO® M290</th>
<th>INOFLO® M295</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Cut</td>
<td></td>
<td></td>
<td>Fine Cut</td>
<td>Fine Cut</td>
<td>Fine Cut</td>
<td>Fine Cut</td>
</tr>
<tr>
<td>Particle Size ($d_{50}$)</td>
<td>ASTM D 4894</td>
<td>µm</td>
<td>25</td>
<td>25</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Bulk Density</td>
<td>ASTM D 4894</td>
<td>g/l</td>
<td>350</td>
<td>350</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Flowability</td>
<td>Mod. ASTM D 1895</td>
<td>g/min</td>
<td>NA</td>
<td>NA</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Std. Specific Gravity</td>
<td>ASTM D 4894</td>
<td>-</td>
<td>2.160</td>
<td>2.165</td>
<td>2.160</td>
<td>2.165</td>
</tr>
<tr>
<td>Tensile Strength (Min.)</td>
<td>ASTM D 4894</td>
<td>MPa</td>
<td>35</td>
<td>34</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Elongation (Min.)</td>
<td>ASTM D 4894</td>
<td>%</td>
<td>500</td>
<td>550</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>Mold Shrinkage (Max.)</td>
<td>ASTM D 4894</td>
<td>%</td>
<td>5</td>
<td>5.5</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>Flex Life</td>
<td>ASTM D 2176</td>
<td>Cycles</td>
<td>&gt;1.5x10^6</td>
<td>-</td>
<td>&gt; 1.2x10^6</td>
<td>-</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>ASTM D 149</td>
<td>kV/mm</td>
<td>90</td>
<td>95</td>
<td>77</td>
<td>80</td>
</tr>
<tr>
<td>Deformation Under Load (14 MPa)</td>
<td>ASTM D621</td>
<td>%</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Note: These are typical properties and not to be used for specification purpose.

**Strengths**

A. Manufactured in a dedicated facility for Granular Modified PTFE resins (ISO 9001, 14001 & 18001 certified)

B. Large production capacities for individual grades

C. Products have been tested and validated for different industrial applications

D. Just-in-time-delivery – Warehouses in Hamburg, Germany & Rockdale, USA

E. Technical support managers located in Europe, USA and India
INOFLON® Modified PTFE resins comply with various industrial regulations & directives as summarized below:

- **REACH – European directive 1907/2006**
  GFL has registration of monomers of concern to make Granular Virgin and Granular Modified PTFE products

- **EC 10/ 2011 (Amendment to directive 2002/72/EC)**
  Plastics materials and articles intended to come in contact with food stuffs

- **EC 1935/2004**
  Plastics materials and articles intended to come into contact with food stuffs repealing directives 80/590/EEC and 89/109/EEC

- **FDA 21CFR 177.1550**
  Perfluorocarbon resins for use as basic components of single and repeated use food contact surfaces

- **REACH – Substances of Very High Concern EC No. 1907/2006**
  Certified as per candidate list updated on December 19, 2011

- **3A – Sanitary standard for multiple use plastic materials**

- **RoHS directive 2011/65/EU**
  Restriction of the use of certain hazardous substances in electrical and electronic equipment

- **ELV – End of Life Vehicles**
  European directive 2000/53/EC

- **United States Pharmacopoeia (USP) Class VI**
  Determination of biological response of animals to direct and indirect contact with the test article or injection of the test article extract

- **UL 94**
  Certification for flammability of Plastics material for parts in devices and applications

For any further details related to certification of specific grades, kindly contact GFL.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Net Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>INOFLON® M690</td>
<td>25 Kg (Pallet Size: 300 Kg)</td>
</tr>
<tr>
<td>INOFLON® M695</td>
<td>25 Kg (Pallet Size: 300 Kg)</td>
</tr>
<tr>
<td>INOFLON® M290</td>
<td>40 Kg (Pallet Size: 480 Kg)</td>
</tr>
<tr>
<td>INOFLON® M295</td>
<td>40 Kg (Pallet Size: 480 Kg)</td>
</tr>
</tbody>
</table>

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