Ticona Engineering Polymers
Performance Driven Solutions™

New Composite Material for Automotive Industry

LFT-POM

(Long Glass Fiber Thermoplastic Polyacetal)

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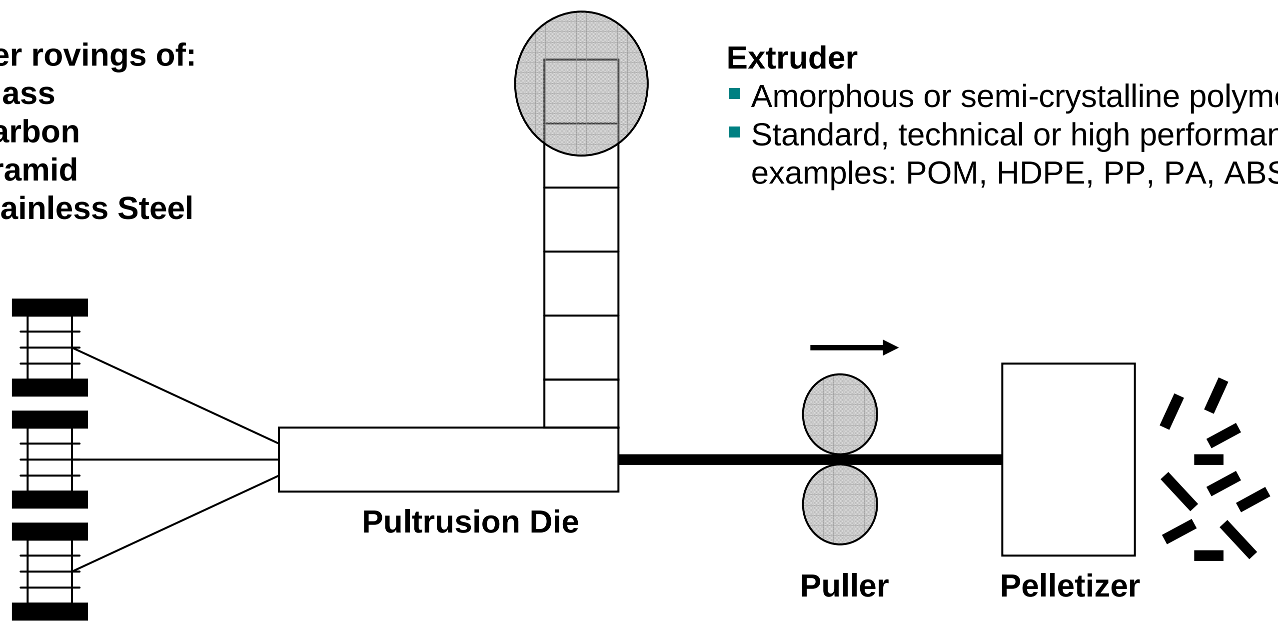
Pultrusion Process – Overview

- Fibers are pulled through the polymer melt and then pelletized according to the desired pellet size.
- This process results in integral fibers completely surrounded by polymer with sizes determined by the pelletizer.
- Process can be used for practically all semi-crystalline and amorphous thermoplastic materials and several combinations of different fiber materials.

Fiber rovings of:
- **Glass**
- **Carbon**
- **Aramid**
- **Stainless Steel**

Extruder
- Amorphous or semi-crystalline polymers
- Standard, technical or high performance polymers examples: POM, HDPE, PP, PA, ABS, PC, PBT, PPS, etc.



Pellets are chopped according to the desired pellet/fiber size

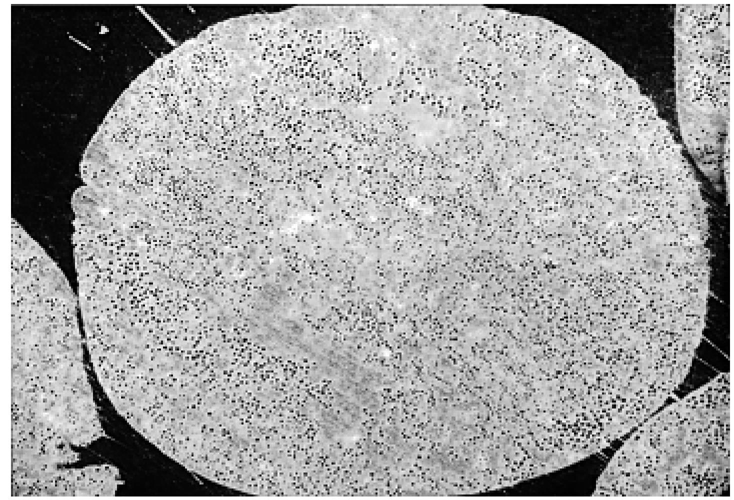
In general, sizes of half and one inch

Pultrusion Process – Key Advantages

Note that all fibers are evenly spaced and completely surrounded by polymer.

This technology generates a “fiber skeleton” inside the part after injection molding, which leads to:

- Higher impact properties
- Lower creep tendency
- Lower warpage problems
- Higher HDT (Heat Deflection Temperature)



Enhanced picture of a sectional area of the pellet

Enhanced picture of an injection molded part before and after bring burned off (the white part represents the glass fiber matrix)

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Pultrusion LFT Compared to Other Common Processes

Advantages of Pultrusion Long Fiber Pellets vs. Short Fiber

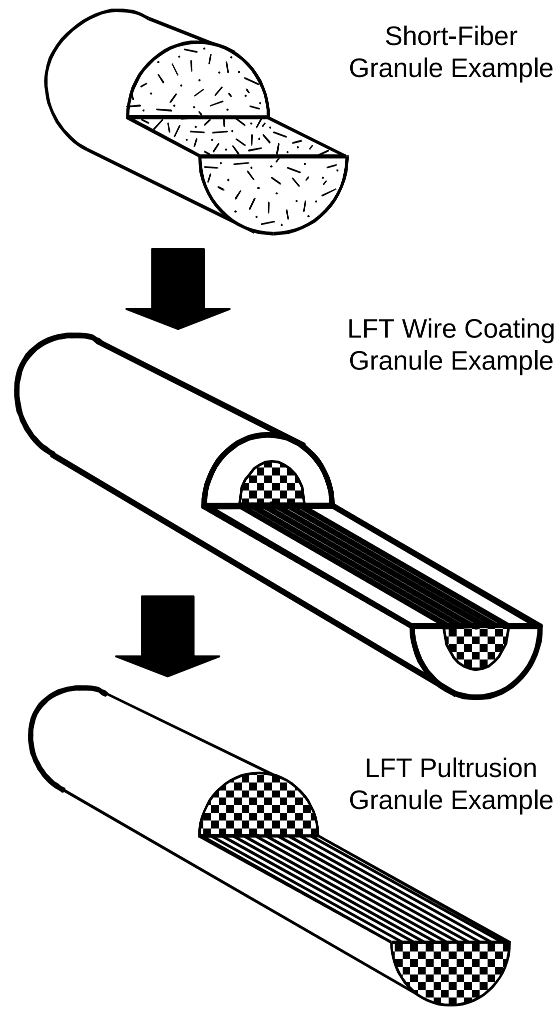
- Higher mechanical properties combined with significantly higher impact strength
- Reduced creep tendency
- Lower warpage and better dimensional stability

Advantages of Pultrusion Long Fiber Pellets vs. Wire Coating Long Fibers

- More homogeneous fiber distribution
- Higher impact strength
- Better surface / part appearance
- Lower wear on cylinder and tool

Pultrusion Granule Schematic

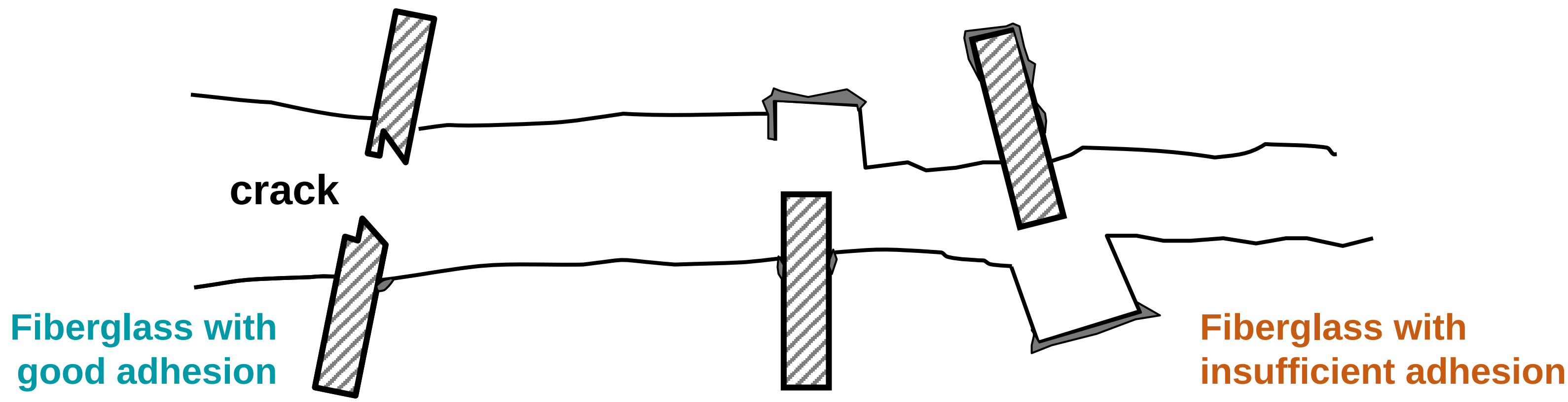
Note the uniform fiber distribution surrounded by polymer matrix throughout the whole pellet.

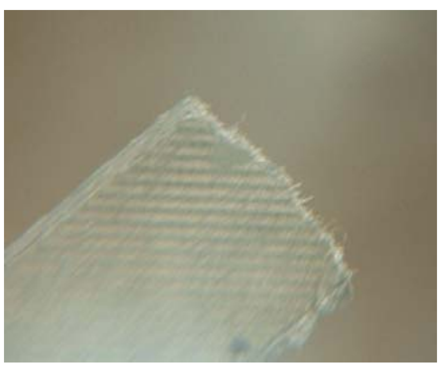


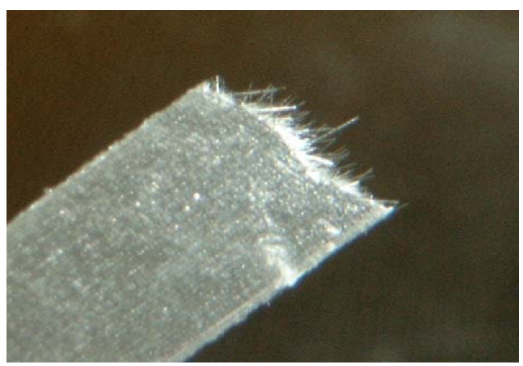
Not Only the Manufacturing Process Matters…

- … the chemistry behind the interface of the glass fiber and the polymer matrix is also very important.

BREAK SURFACE EXAMPLE



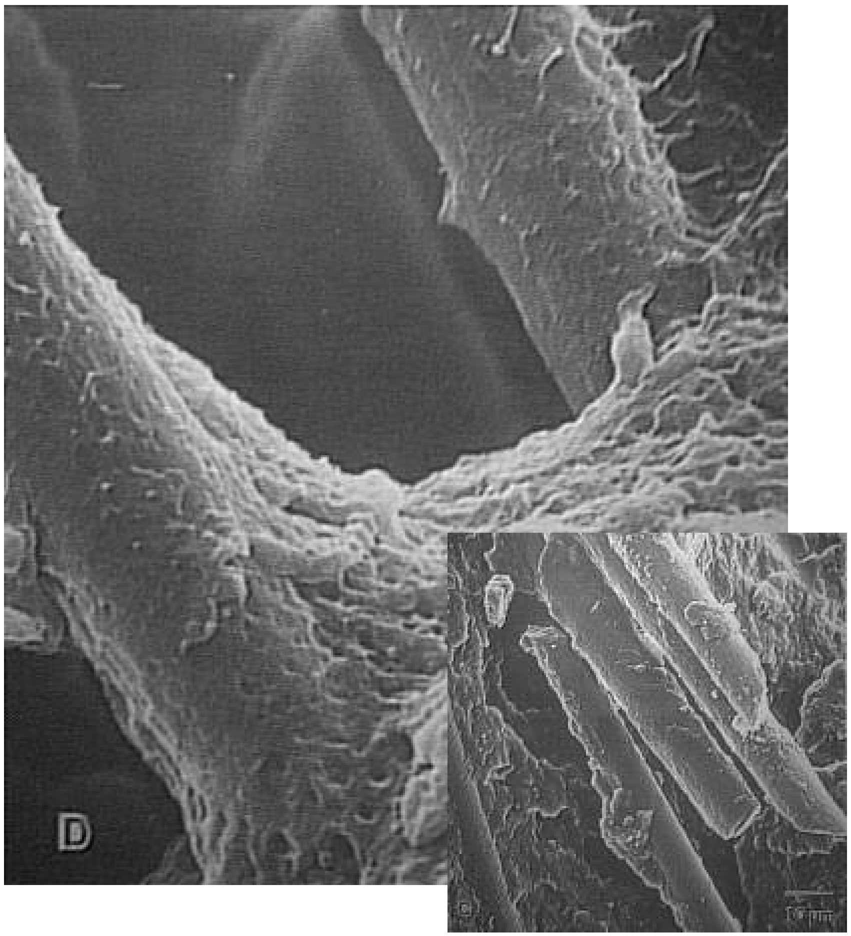




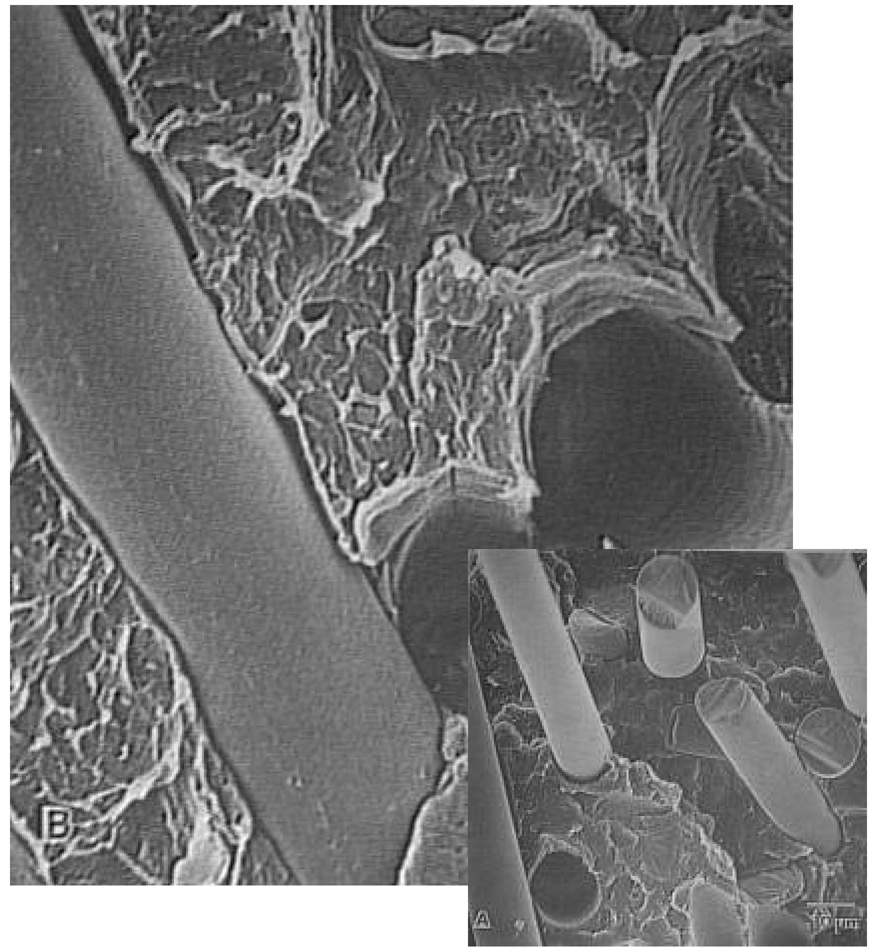
Note the loose fibers on the right. That indicates that the fibers do not have chemical bonding between the fiber and the polymer matrix.

Break Surface
(Fiber/Matrix Adhesion, REM Pictures)

Good Adhesion Example



Insufficient Adhesion Example



The Function of the Coupling Agent

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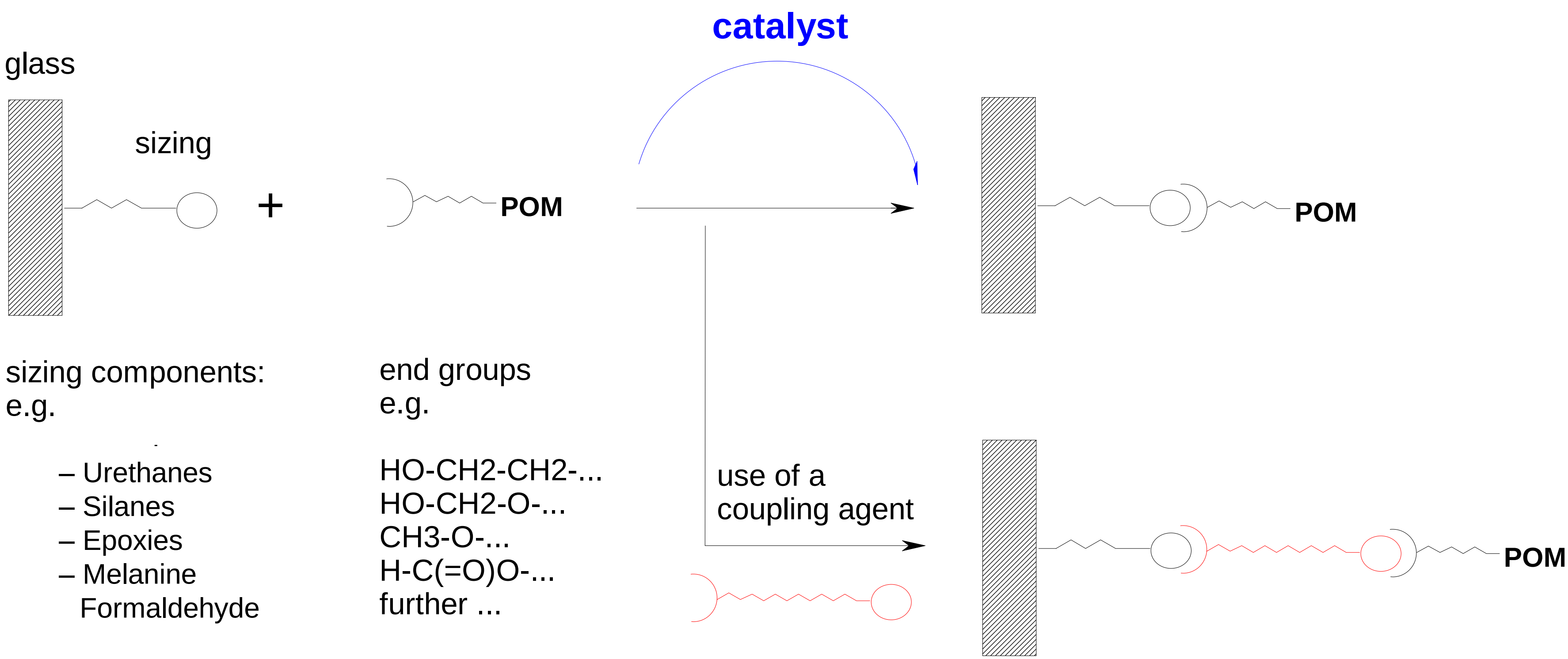
Scheme of the interfacial coupling reaction between glass fibers and POM



sizing components:
e.g.

- Urethanes
- Silanes
- Epoxies
- Melanine
  Formaldehyde

end groups
e.g.

HO-CH2-CH2-...
HO-CH2-O-...
CH3-O-...
H-C(=O)O-...
further ...

New LFT-POM from Ticona

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- Combines the pultrusion manufacturing process benefits together with a new advanced coupling chemical technology to provide a step change in the product properties.
  - Since the product is still under development, all property values are from preliminary lab and production trials.

- The following property data for comparison was taken from the products below:
  - Hostaform® C 9021 GV1/30
    - Copolymer Polyacetal reinforced with 26% Short Glass Fiber
  - Celstran® POM GF-40-01 (old generation of LFT-POM)
    - Copolymer Polyacetal reinforced with 40% Long Glass Fiber
  - Celstran® PP-GF40-04
    - Polypropylene reinforced with 40% Long Glass Chemically Coupled Fiber
  - Celstran® PA66-GF30-02
    - Heat stabilized Polyamide 66 reinforced with 30% Long Glass Fiber

Comparison of New LFT-POM versus other POM products

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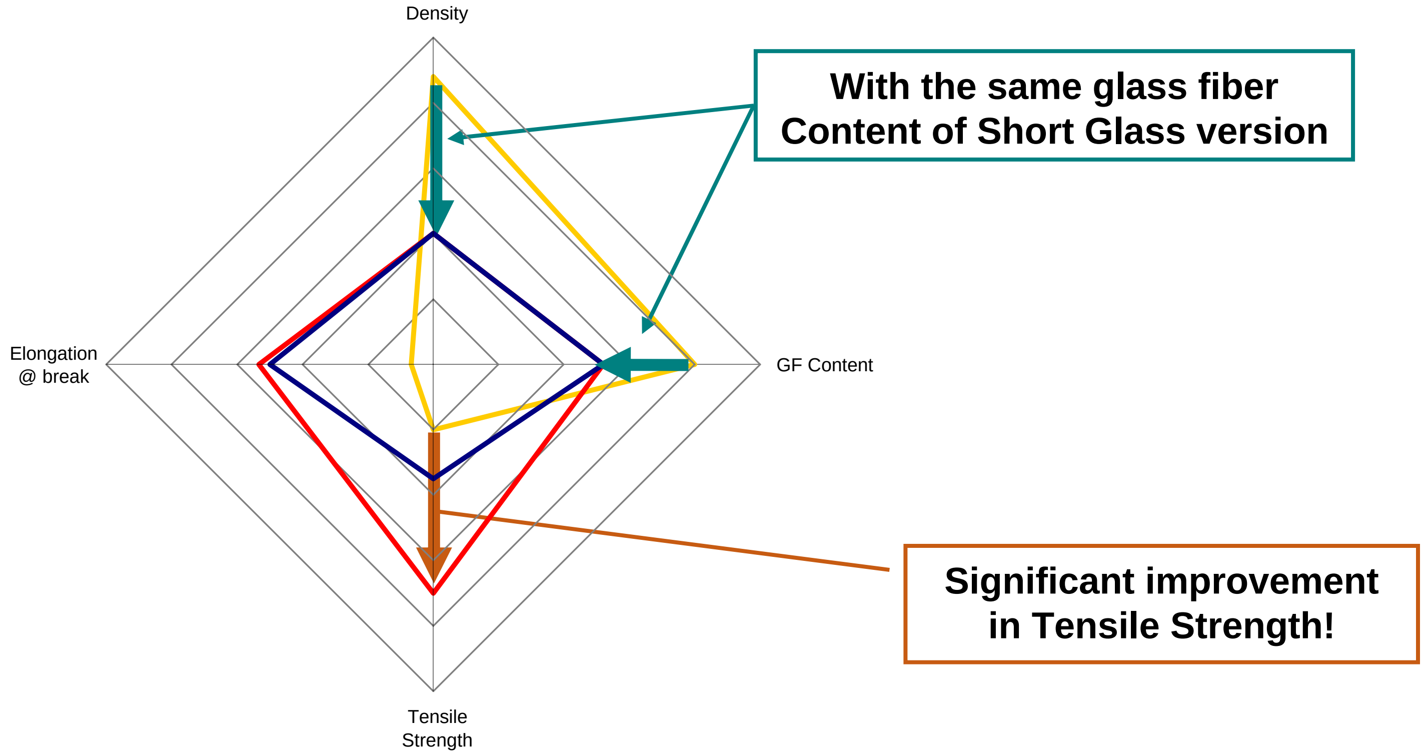

Property	Unit	Test Method	Temperature	Hostaform® C 9021 GV1/30	Celstran® POM-GF-40-01	Celstran® POM-GF26
Density	g/cm^3	ISO 1183	23°C	1.60	1.72	1.60
GF Content	%	ISO 3451, part 1		26	40	26
Tensile Strength	MPa	ISO 527, part ½; test speed 5 mm/min		135	120	170
Elongation @ Break	%	ISO 527, part ½; test speed 5 mm/min		2.5	1.21	2.6
Tensile Modulus	MPa	ISO 527, part ½; test speed 5 mm/min		9200	13400	9500

Comparative Data Versus Other Products

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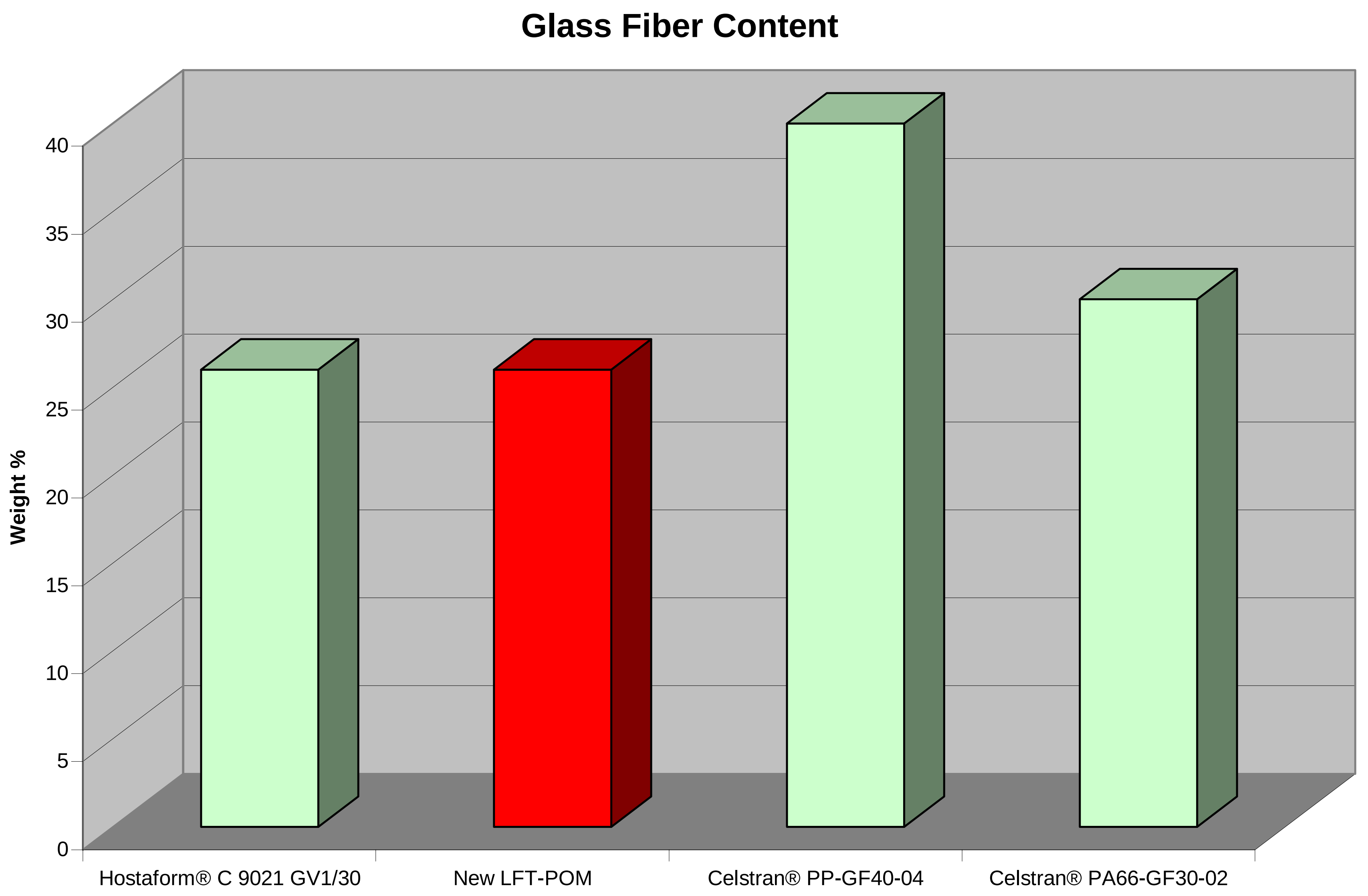

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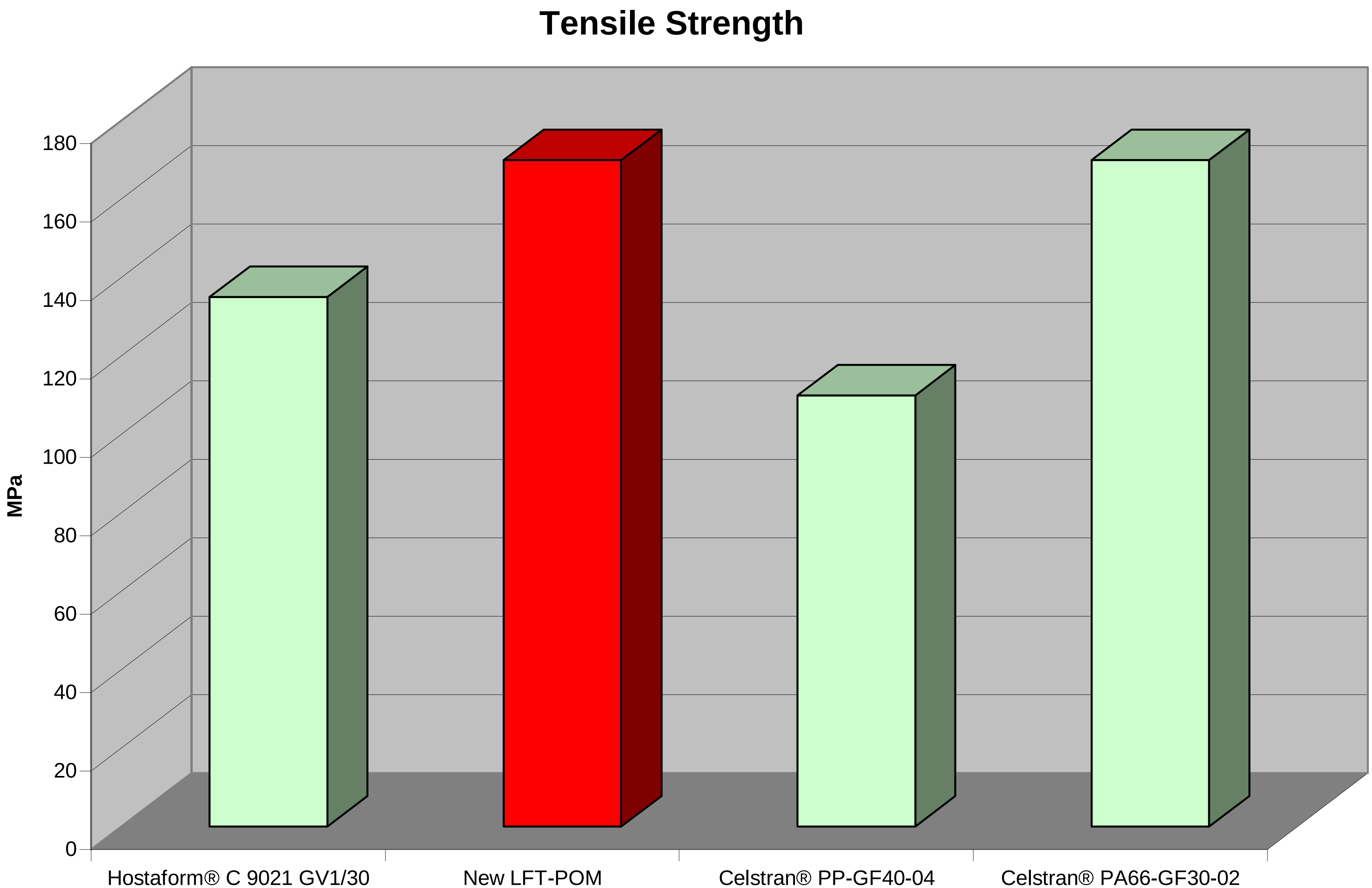

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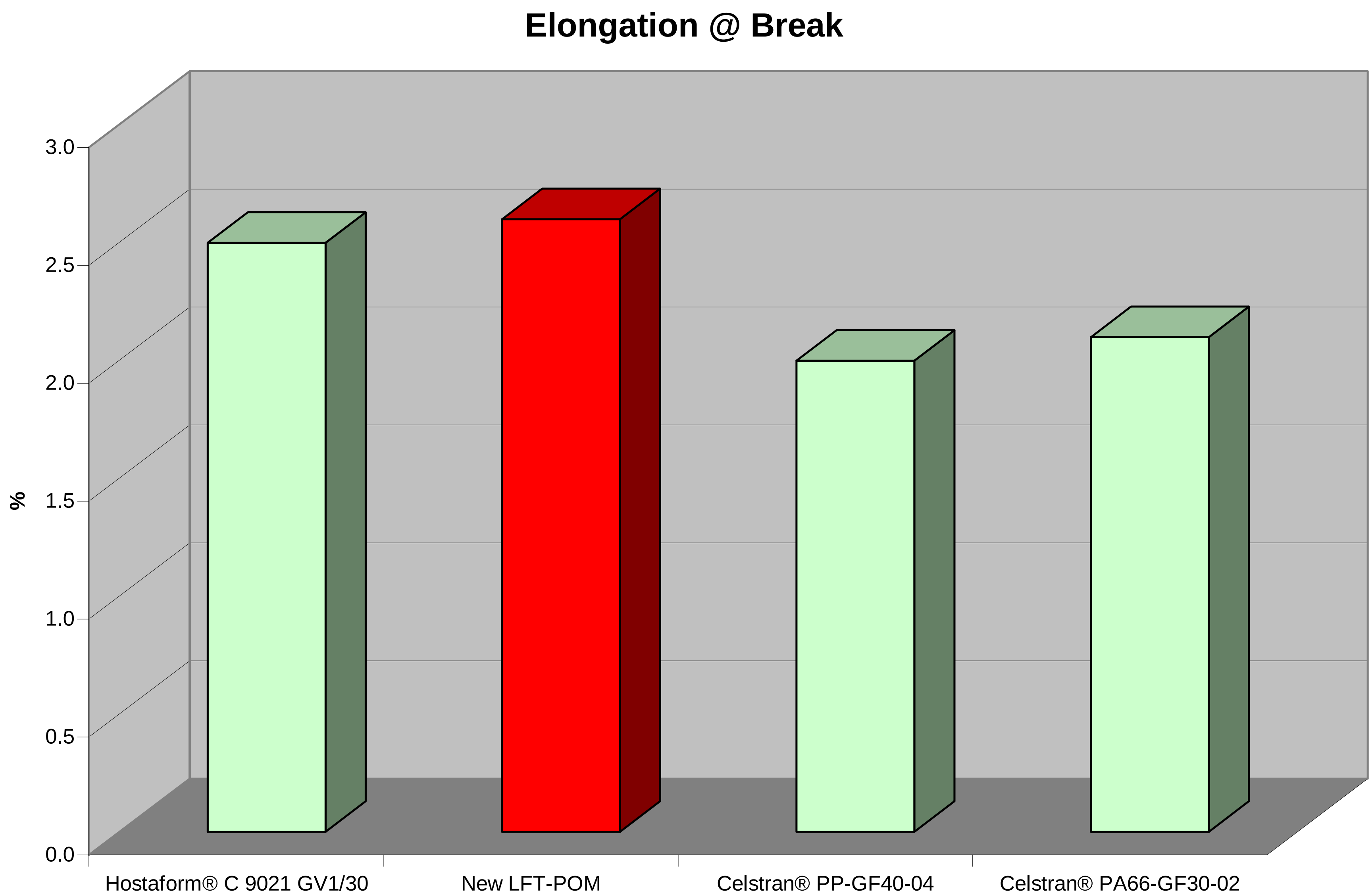

Comparative Data Versus Other Products

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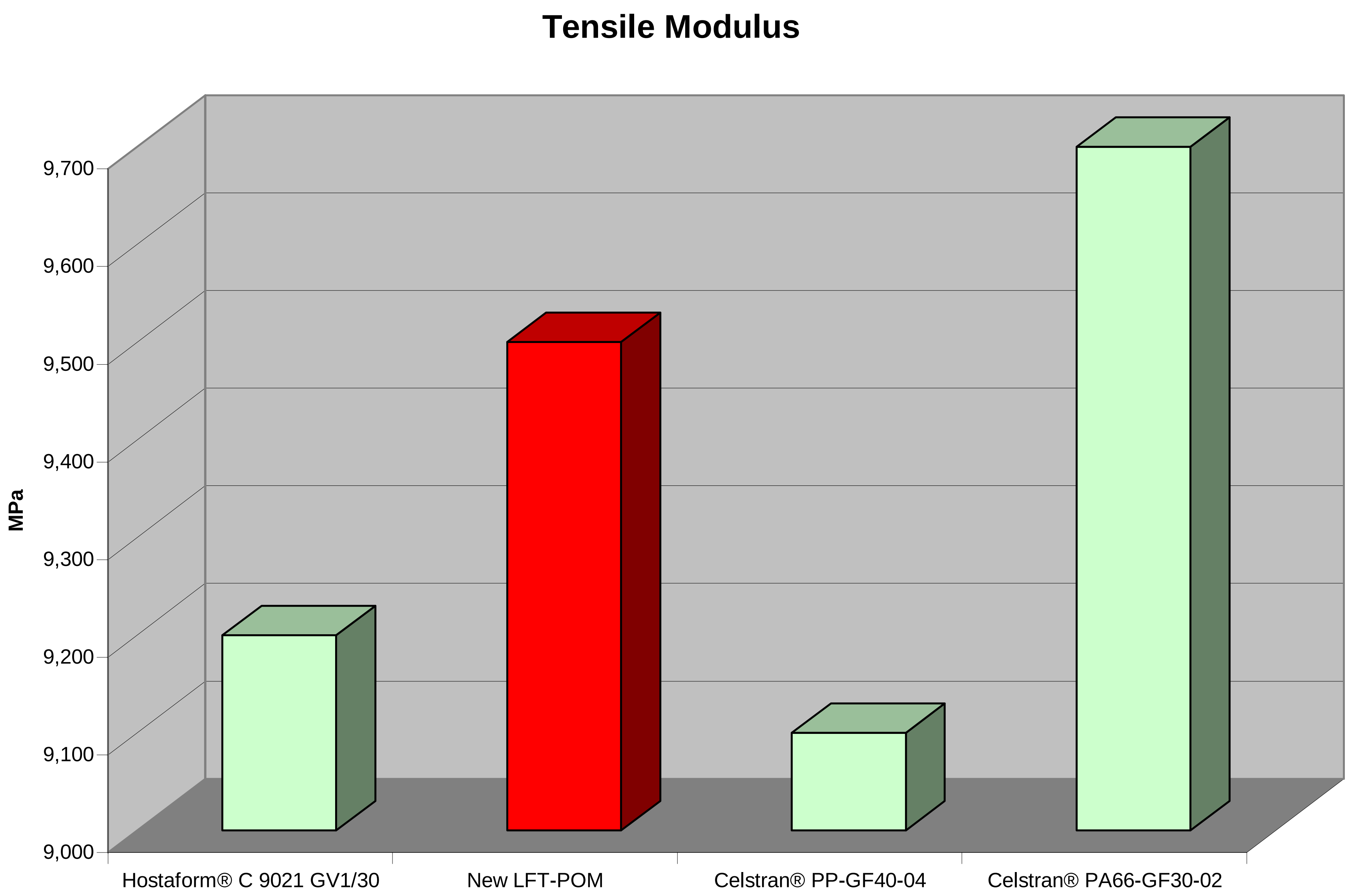
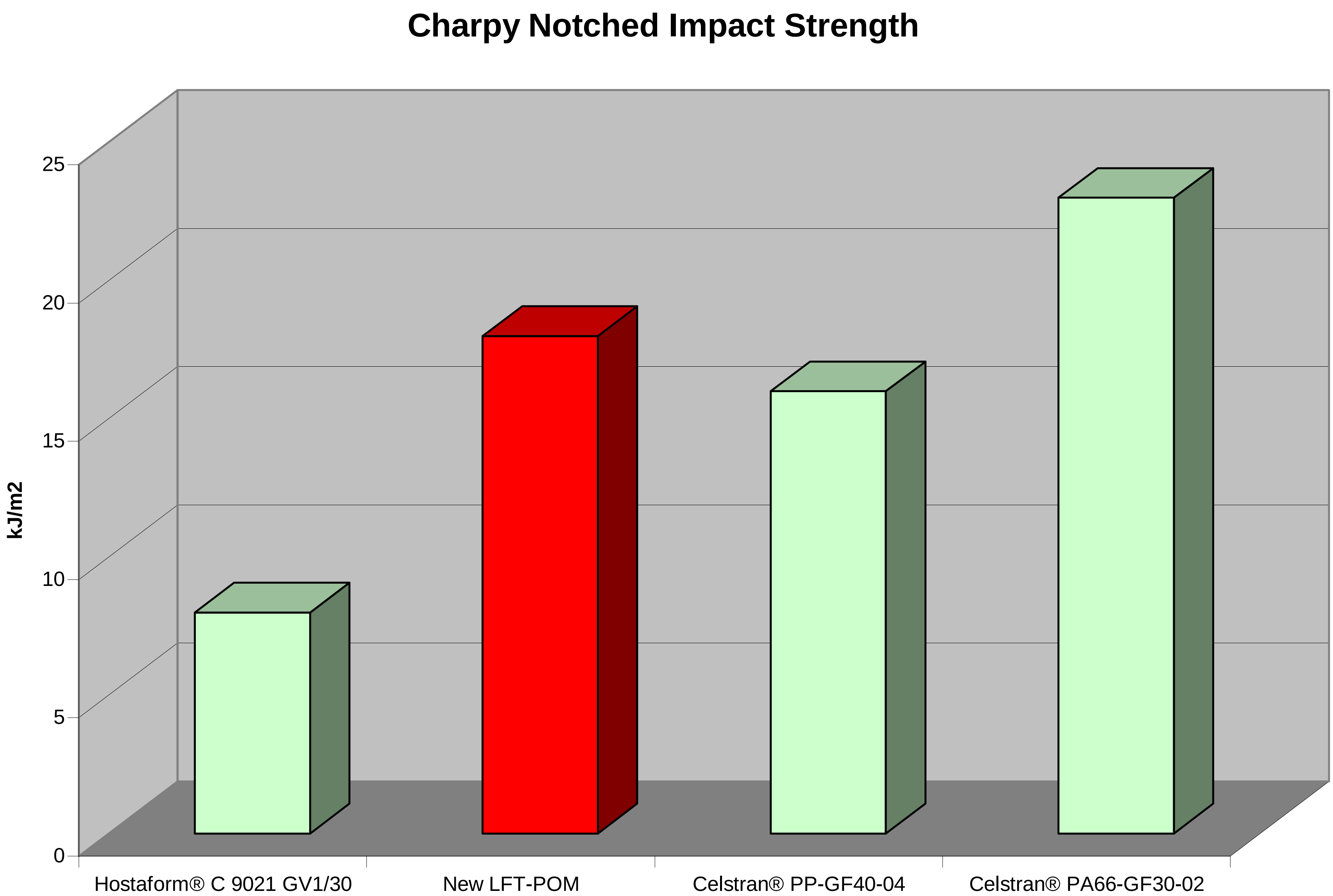


Comparative Data Versus Other Products



Value Proposition

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Density	g/cm^3	ISO 1183	23°C	**1.60**	**1.60**	**1.72**	**1.60**
GF Content	%	ISO 3451, part 1		**26**	**26**	**40**	**26**
Tensile Strength	MPa	ISO 527, part ½; test speed 5 mm/min		**135**	**170**	**120**	**170**
Elongation @ Break	%	ISO 527, part ½; test speed 5 mm/min		**2.5**	**2.6**	**1.21**	**2.6**
Tensile Modulus	MPa	ISO 527, part ½; test speed 5 mm/min		**9200**	**9500**	**13400**	**9500**
Charpy Notched Impact Strength	kJ/m2	ISO 179 1eA		**8**	**18**	**16**	**23**

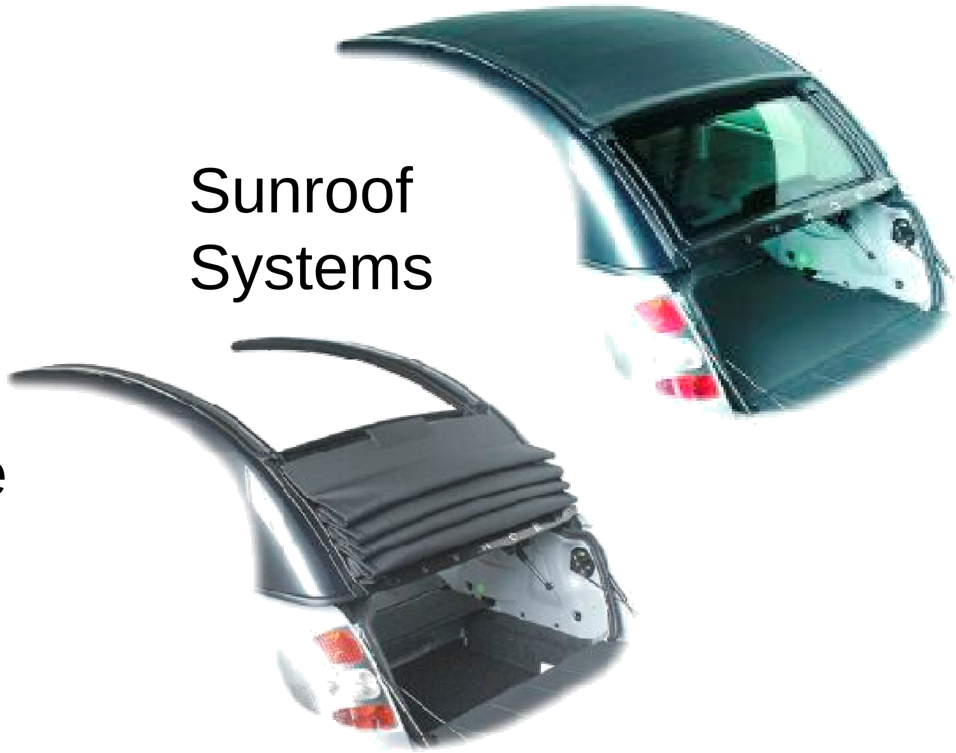
- **Inherent lubricity**
- **Higher mechanical properties**
  - Stiffness
  - Impact
  - Creep
- **Chemical resistance**
- **Low warpage**
- **Good surface appearance**
- **Higher temperature resistance, compared to olefin-based long fiber reinforced materials**
- **Low moisture absorption**

Potential Applications for New LFT POM in Automotive Industry

Potential Benefits:

- Higher stiffness
- Inherent lubricity
- Creep resistance
- Chemical resistance
- Good surface appearance
- Higher HDT

Sunroof Systems



Potential Applications for New LFT POM in Automotive Industry

Potential Benefits:

- Higher stiffness
- Impact strength
- Inherent lubricity
- Creep resistance
- Chemical resistance

Seating Systems

Potential Applications for New LFT POM in Automotive Industry

Potential Benefits:

- Higher stiffness
- Inherent lubricity
- Creep resistance
- Chemical resistance
- Higher HDT

Wiper Systems

Potential Applications for New LFT POM in Automotive Industry

Potential Benefits:

- Higher impact strength
- Creep resistance
- Chemical resistance
- Higher HDT

Fuel System Components

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Questions/Comments?

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Thank you for your time!
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