Elium®
Liquid thermoplastics

- Room temperature cure
- Very high stiffness
- Ductile composites

ELIUM®
BY ARKEMA

ELIUM® BY ARKEMA

Unique Technology

- **Liquid thermoplastic** composite resin
- Easy to process with existing infrastructure (at low T)
- Similar mechanical properties versus epoxy with…
  - Improved impact
  - Easy welding
  - **Thermoforming**

Proven Results

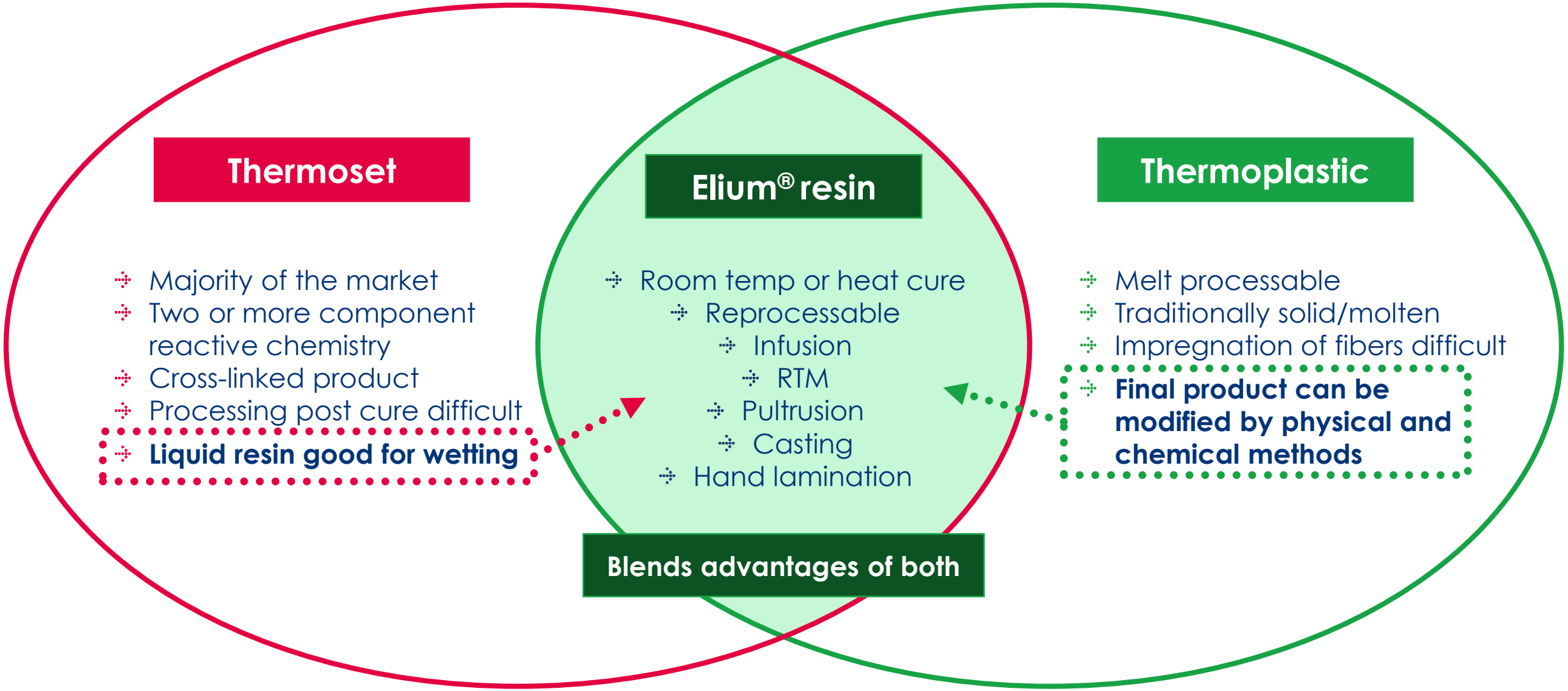
- JEC Innovation Award 2017
- JEC Asia Award 2017
- CAMX 2017 Combined Strength finalist
- CAMX 2018 JEC Innovation 2018 - Sustainability finalist

An Exciting Future

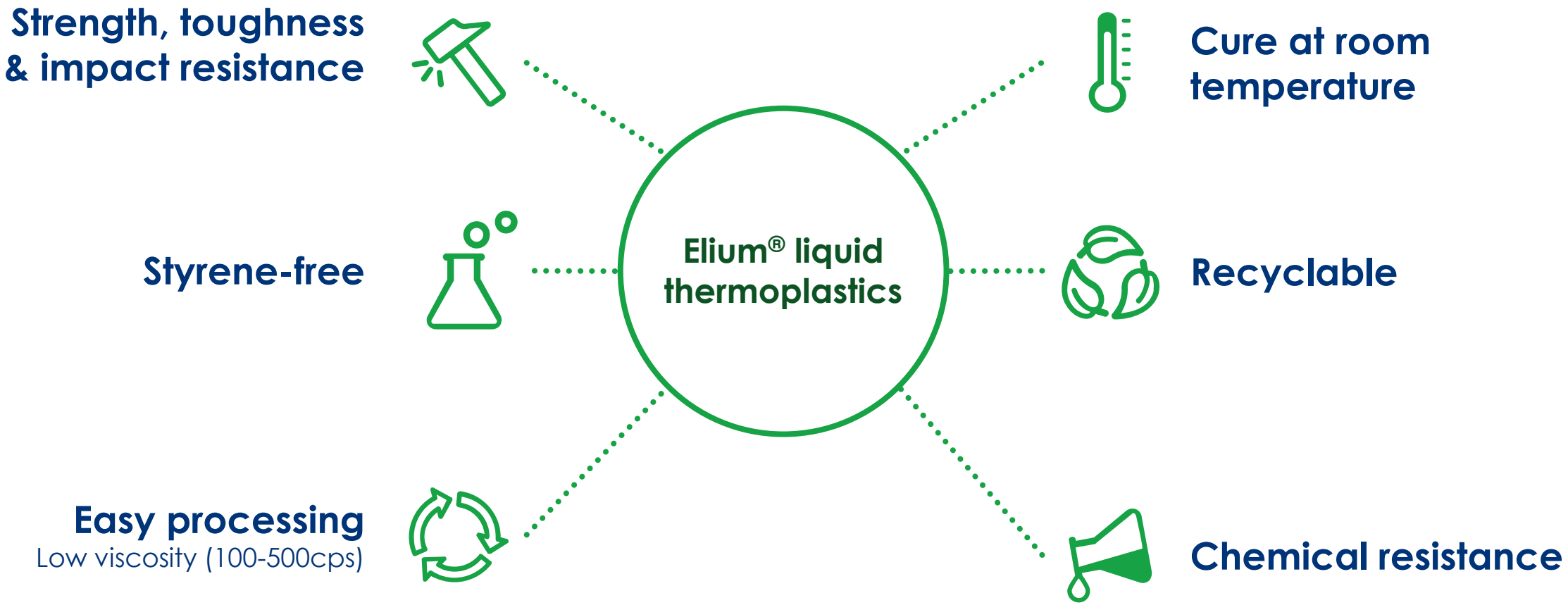
- Lightweight options
  - **Do more with less**
- **Recycling** options
  - Reprocessing
  - Depolymerize + use again
- Next generation
  - SMC resins
  - Dual cure systems

Production in all 3 major regions

Thermoset vs. Thermoplastic

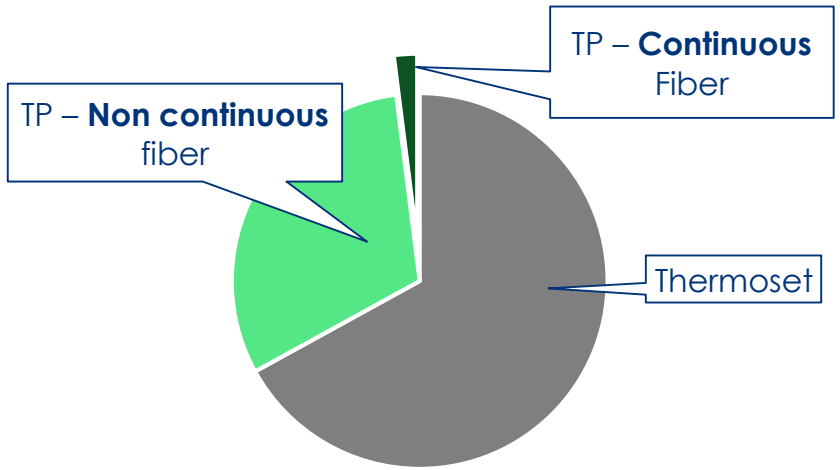


Benefits of Elium® liquid thermoplastics



Continuous fiber vs. Non-continuous fiber for composites

Composite resin market

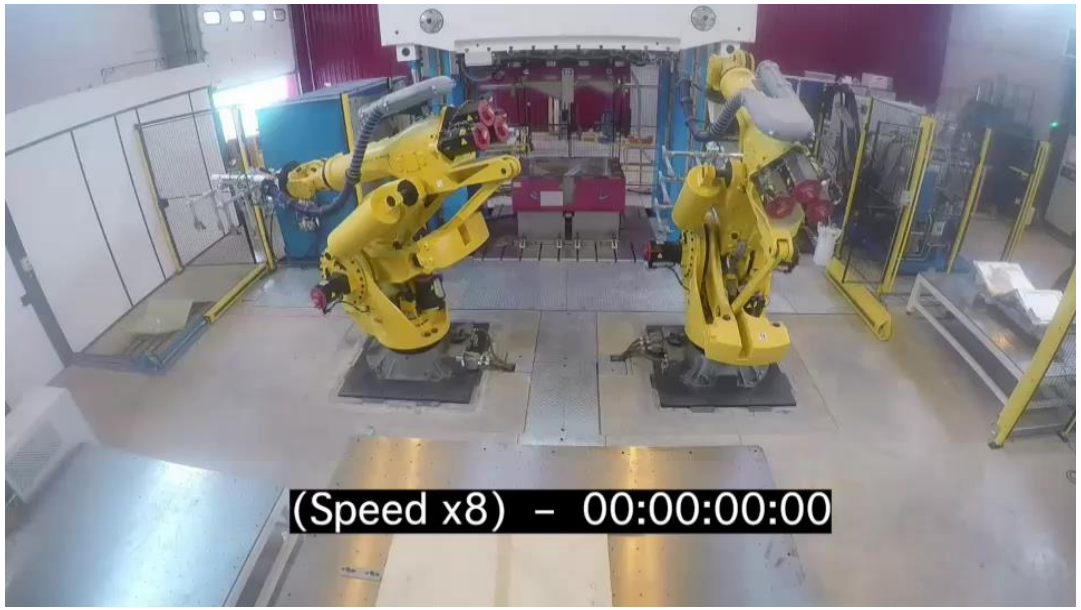


- **Continuous fibers**
  - Stronger mechanical properties
  - More difficult to impregnate with resin
- **Non-continuous fibers**
  - Weaker properties
  - Easier to impregnate with resin

Elium® liquid thermoplastics enable easy impregnation at room temperature for both non-continuous AND continuous fibers

Award Winning Fast-Resin-Transfer-Molding (Fast-RTM)

JEC GROUP WINNER OF 2017 INNOVATION AWARD



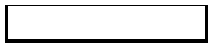
Glass fiber reinforced Elium® resin demo part made on Fast-RTM pilot line

- Pilot line operates with thermoplastic (Elium® resin from Arkema) or Thermoset resins (Epoxy from Hexion)
- Targeting < 2 minutes part to part production cycle time

Aesthetic parts – Class A finish out of the mold

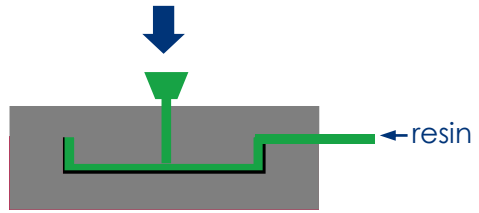
**New RTM-TS (RTM-Thermoformed Sheet) in development

Thermoforming of a PMMA-ABS Class A sheet



The PMMA-ABS sheet is laid up in the RTM mold

Lay-up of reinforcement (UD, fabric, NCF …), and inserts if any



Counter mold is closed and resin injected at low to medium pressure

Resin polymerization

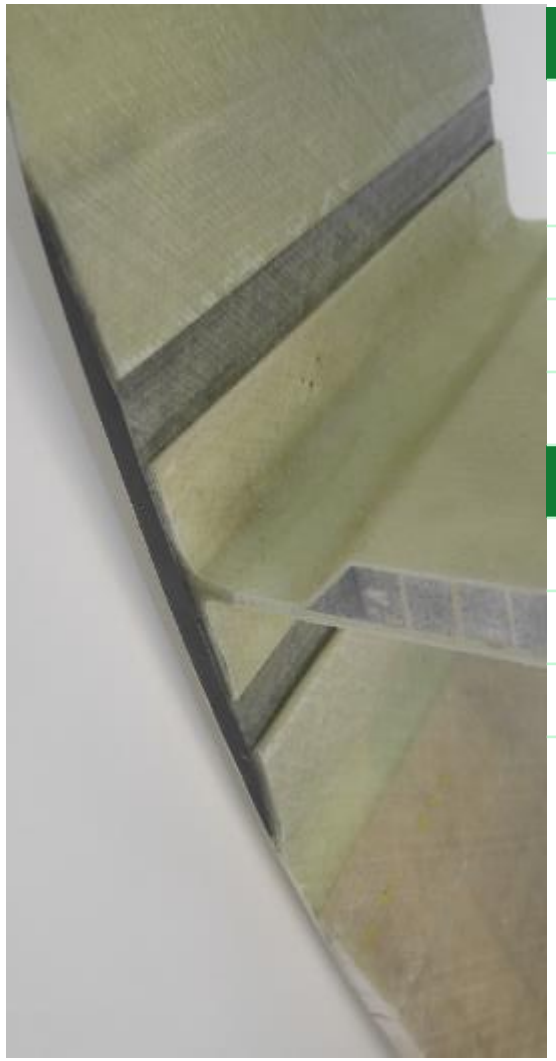
Mold opening and demolding of the part

No coating due to Class A PMMA-ABS finish

High gloss
No painting

- **Aesthetic parts**
- **Class A finish (PMMA-ABS sheets) without post coating**
- **200 to 10k parts/yr**

Thermoplastic pultruded parts – Elium® 591 GF/CF



Elium® 591 GF	Value	Unit
Barcol Hardness	**64** (± 8)	
Stiffness at 0°	**43** (± 1)	GPa
Strength at 0°	**1200** (± 60)	MPa
Stiffness at 90°	**8.7** (± 0.3)	GPa
Strength at 90°	**52** (± 3)	MPa
Elium® 591 CF	**Value**	**Unit**
Fibers volume fraction	70	%
ILSS	82	MPa
Tensile modulus	155	GPa
Tensile strength	2300	MPa

- **Elium 591 for pultrusion with glass or carbon fiber**
- **Resulting parts are:**
  - Easy to bond
  - Thermoformable
  - Weldable

Properties of Elium® thermoplastic composites



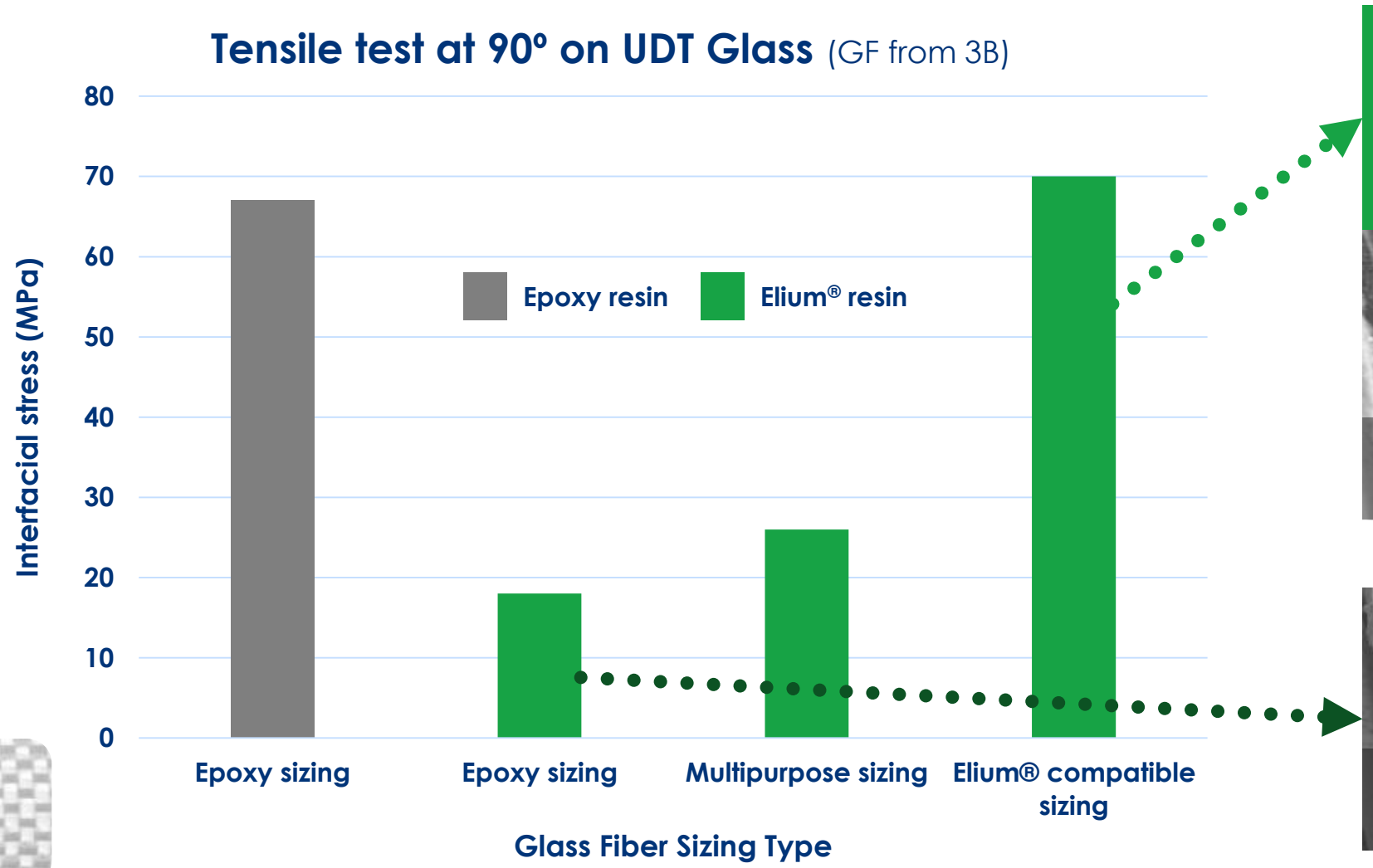
Property	Pure Elium® resin	Elium® resin + Carbon Fiber	Elium® resin + Glass Fiber	Unit	ISO Method
Tensile strength	**76**	**1280**	**557**	MPa	527
Tensile modulus	**3,300**	**59,000**	**27,000**		
Flexural strength	**130**	**870**	**700**		14125
Flexural modulus	**3,250**	**65,000**	**27,000**		
Compressive strength	**130**	**480**	**347**		14126
Compressive modulus	**-**	**54,000**	**28,000**		

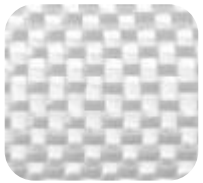
Details: ELIUM® RT-300 resin, room temperature RTM process | Carbon – T700SC 12K NCF 53%vol. | Glass - Chomarat 600T PW fabric 600GSM, 53%vol.

Function	Flex Modulus	Applications
Aesthetic	10 - 15 GPa	Marine, Transportation, Heavy Equipment, etc.
Structural	20 - 45 GPa	Automotive, Aerospace, Wind Blade, Sport, etc.

Basic mechanical properties similar to epoxy
with same reinforcement loadings

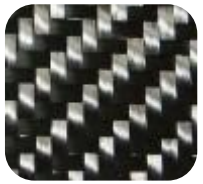
Glass-reinforced structural parts – sizing selection is important!

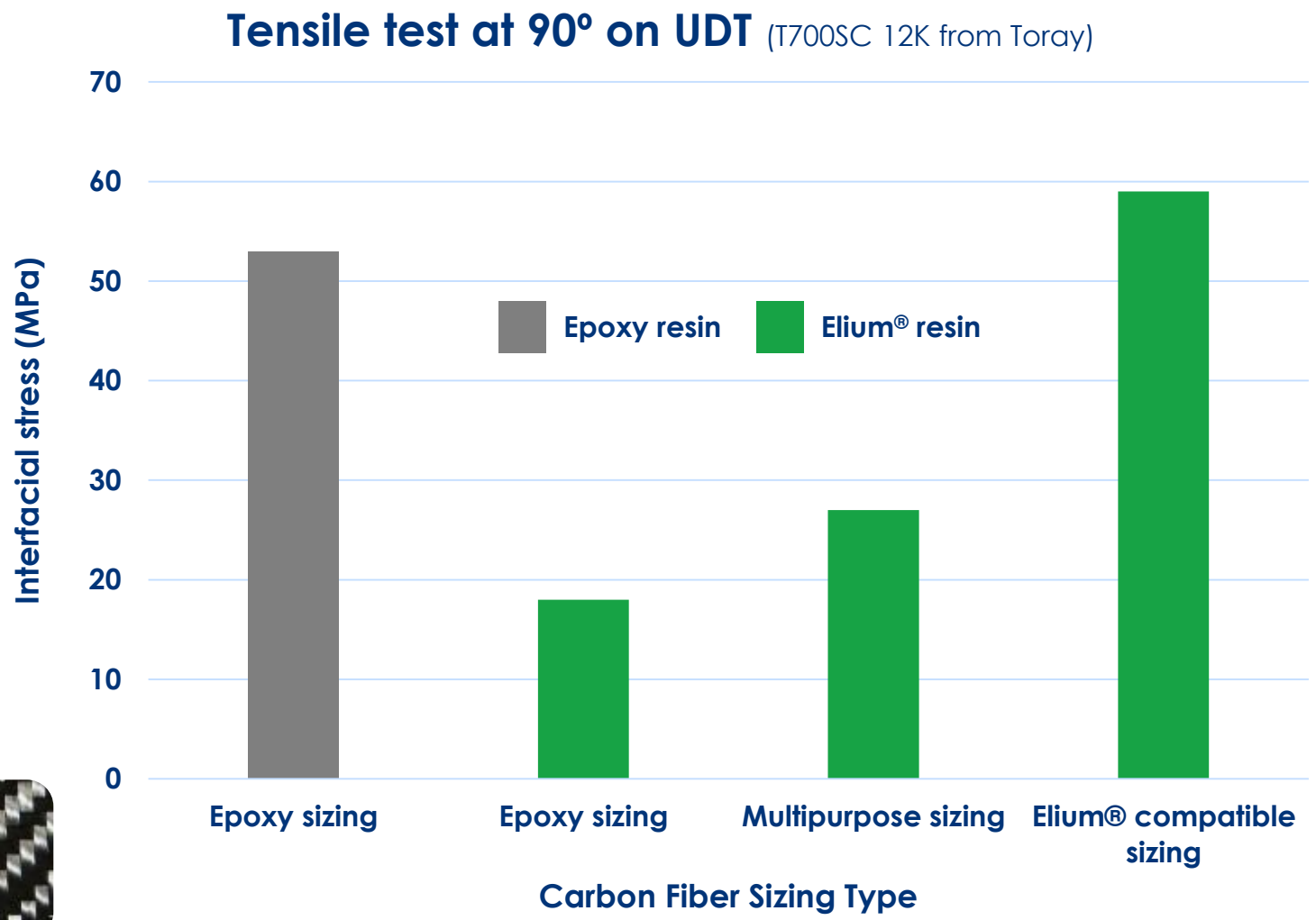




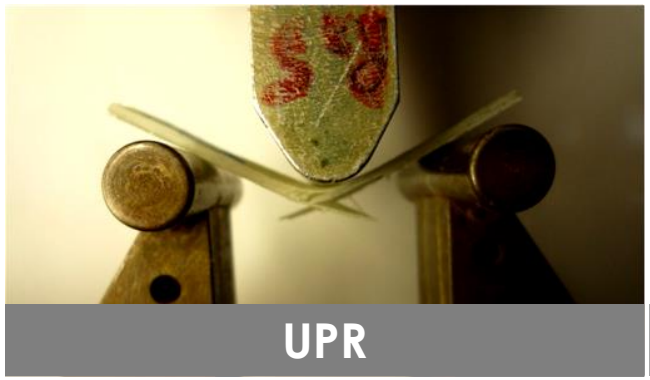
Choose glass fiber with a poly(vinyl)ester compatible sizing

Carbon-reinforced structural parts – sizing selection is important!





High modulus & toughness


UPR


Epoxy

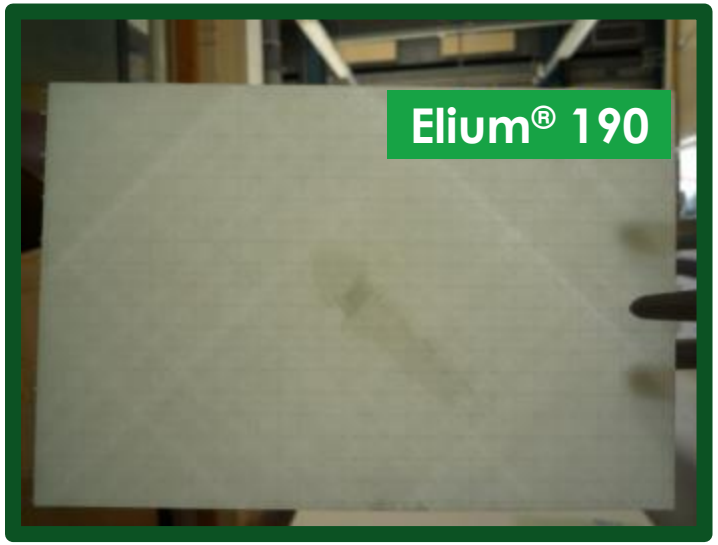

Elium® 180

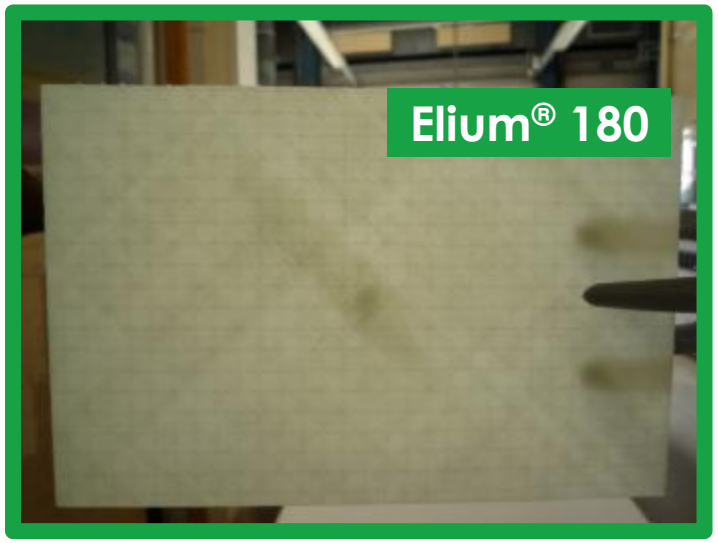
	UPR	Epoxy	Elium® resin
Max stress (MPa)	210	250	**343**
Modulus (Gpa)	13	9	**11**
Elongation at break (%)	2.7	4.8	**> 20**

ISO 14125 flexural test
Vacuum infusion process
2 lies of GF BX45 1200GSM
Sizing SE2020 for epoxy and SE4740 for UPR and Elium® 180

EXCELLENT STIFFNESS **SUPERIOR** TOUGHNESS

Impact and damage tolerance

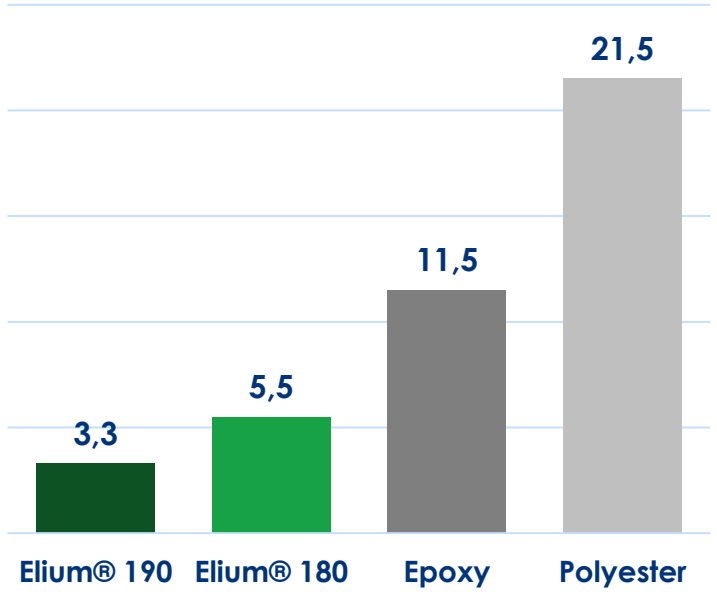




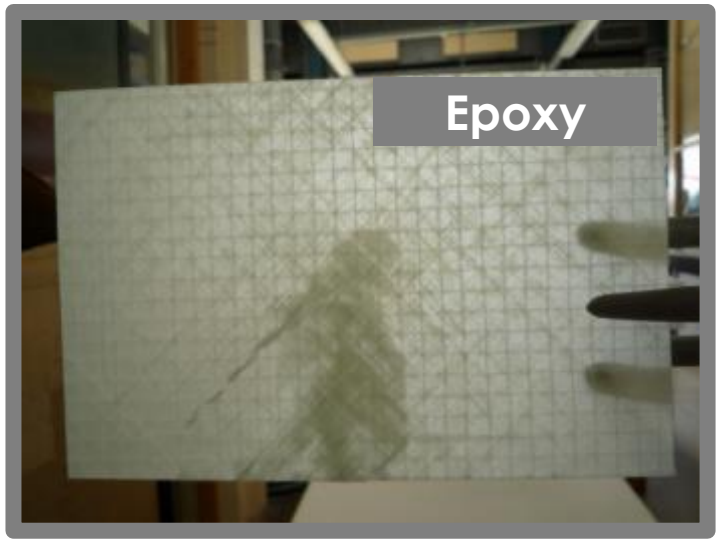
Dart Drop Test

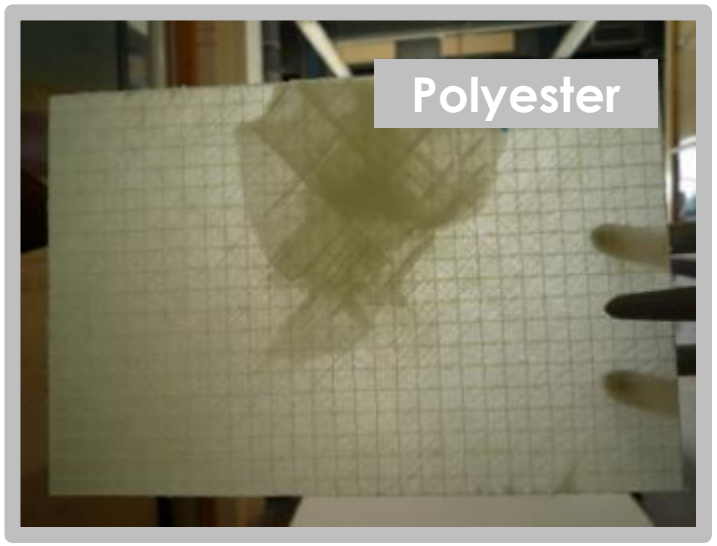
Delamination Area (%)

DYNATUP 26J – 4 m/s



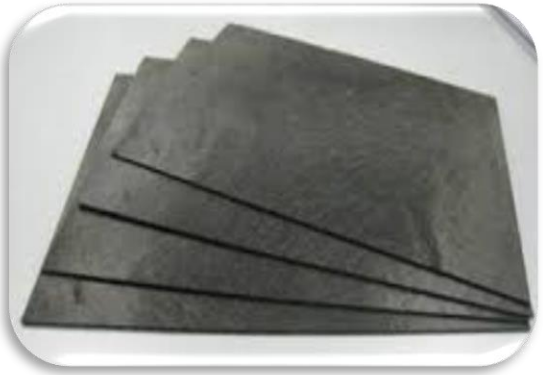
****Elium® resin can be thermoformed to repair delaminated area****





Thermoforming

- **When "cured" Elium® resin remains fully thermoplastic**
  - Allows for post-forming
  - Excellent aesthetics; clarity and surface finish



Courtesy of Savoie Composite Solutions

Courtesy of Savoie Composite Solutions

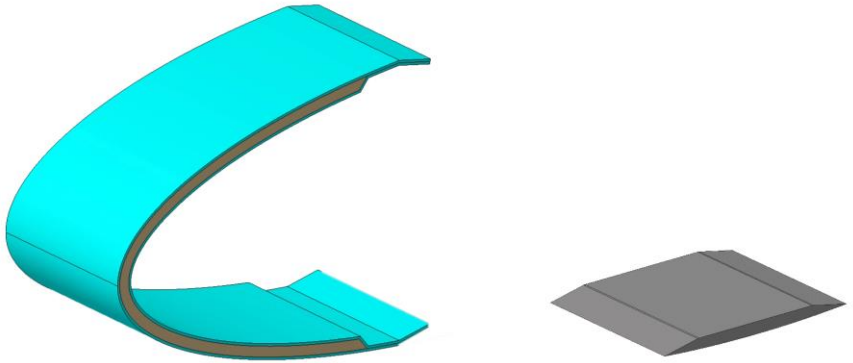
- **Forming conditions**
  - ~200°C and 15 - 20 bar applied pressure (~250 PSI)
  - Degree of draw and applied pressure are dependent on thickness and reinforcement type used in the part

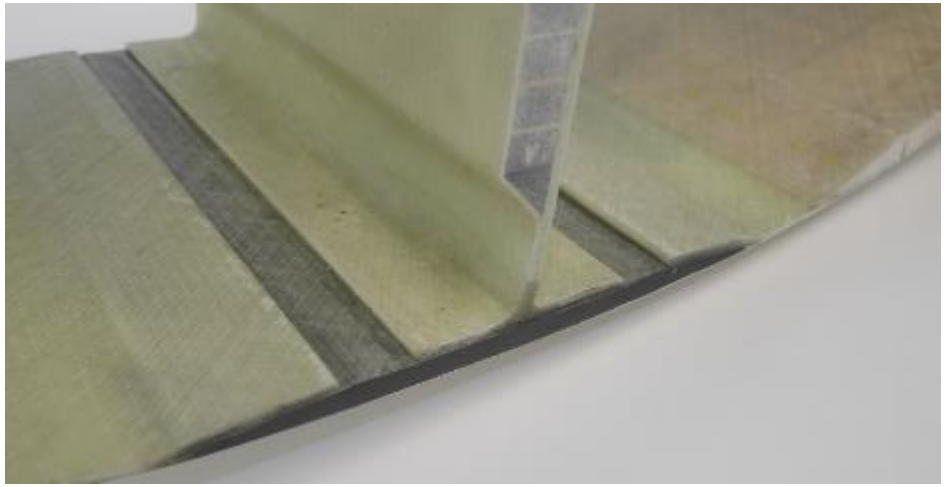
Complex bends

90° bends

Welding solutions

- **Elium® resin composites can be welded together**
- **Blade demonstrator**
  - Show possibilities
- **Welding**
  - Quick process
  - Reduces waste
  - Uniform materials → Easy recycling





Note: All surfaces A side

Recycling – compounding

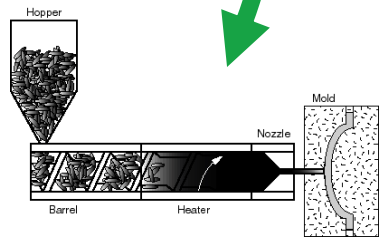
End-of-life composite part
or production waste

Grinding

20 – 40%

Compounding
(ABS, PLA, PMMA, etc.)

Short fiber compound



Injection molding of short fiber compound

NEW Composite part

	Commercial compound ABS-GF20	ABS + 40% recycled Elium® resin
Injection	Same conditions	
Stiffness	4.9 GPa	**6.9 GPa**
Strength	69 MPa	**76 MPa**
Charpy Impact	13 kJ/m²	**22 kJ/m²**

Improvement of short fiber ABS compound when recycling Elium® composites

Recycling – depolymerization

Elium®-R

De-polymerization

High Temperature
Under Nitrogen

+

Purity > 99%

Polymerization

Hood (GRP, ABS-PMMA sheet)
**MVC Plasticos*

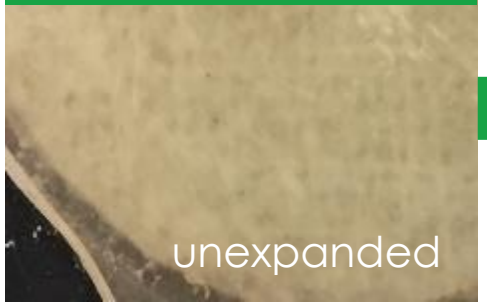
Separation Fibers / Metal

Light-weighting methods & process development

Elium® composite

5 wt% glass bubbles

5 wt% Expancel®



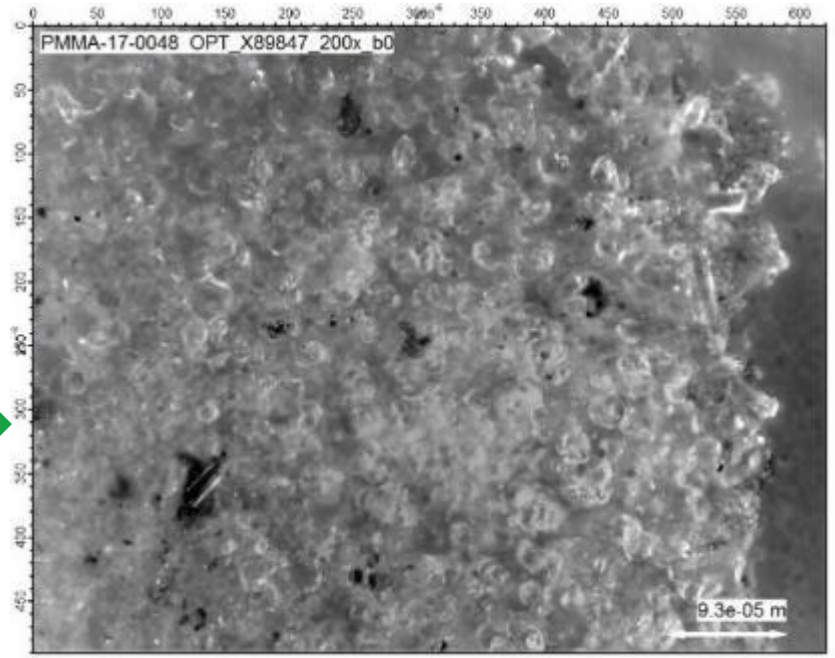
- **Glass Bubbles → Rheology modifier for stable dispersion**
- **Expancel® microspheres → easily dispersed, stable in Elium® resin**
  - Dry expanded microspheres: one step; possible filtering
  - Dry unexpanded microspheres: post-heat; lower viscosity

Convection Oven

- lower density
- uneven surface

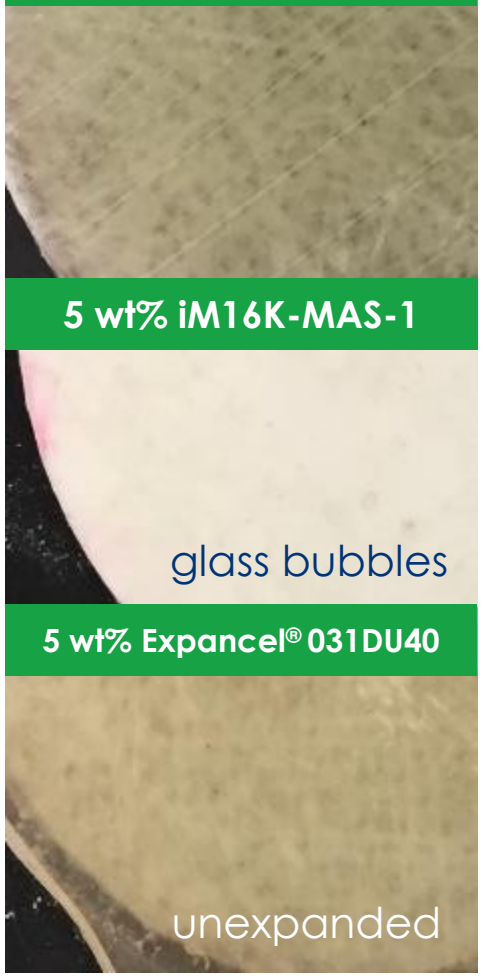
Closed Mold or Press

- higher density
- Smooth surface

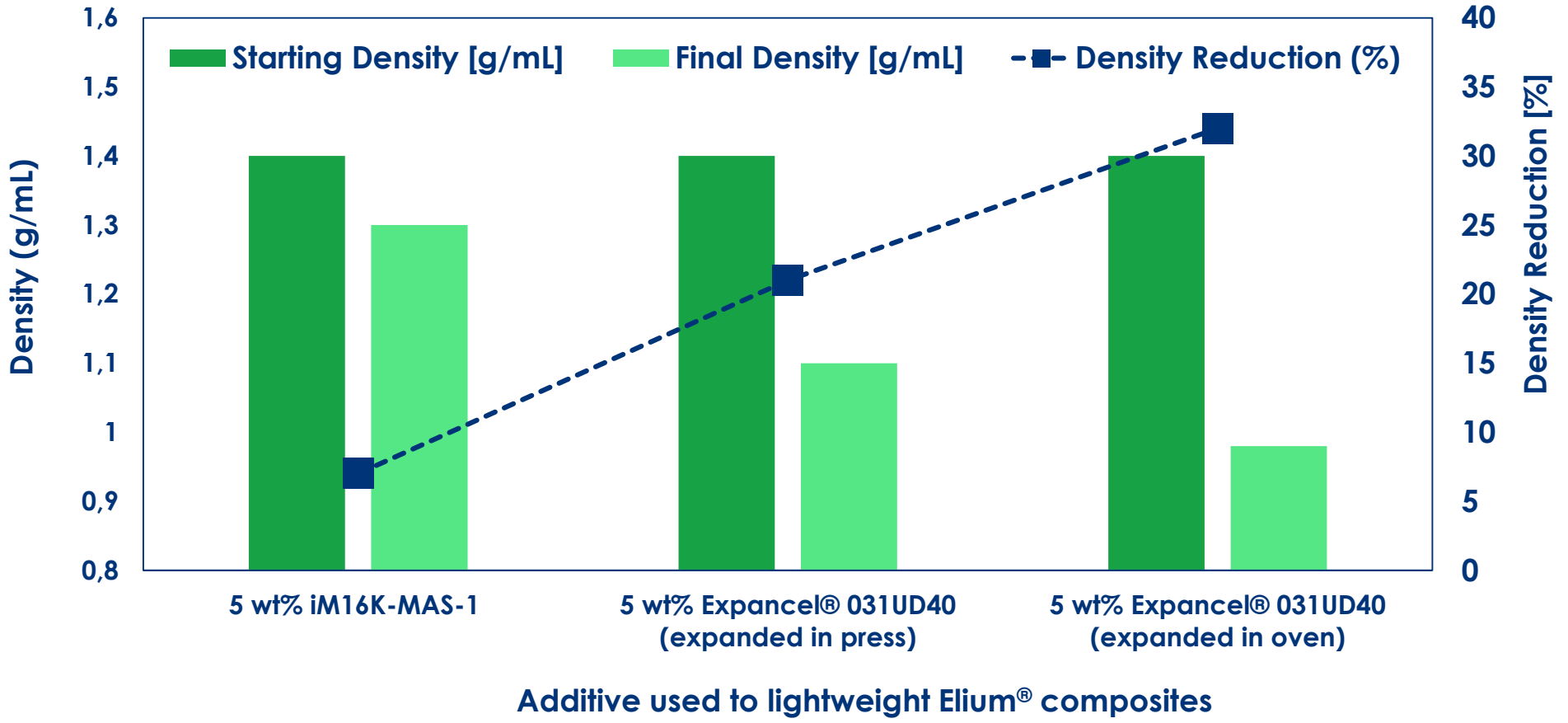


Density reduction comparison

Elium® composite



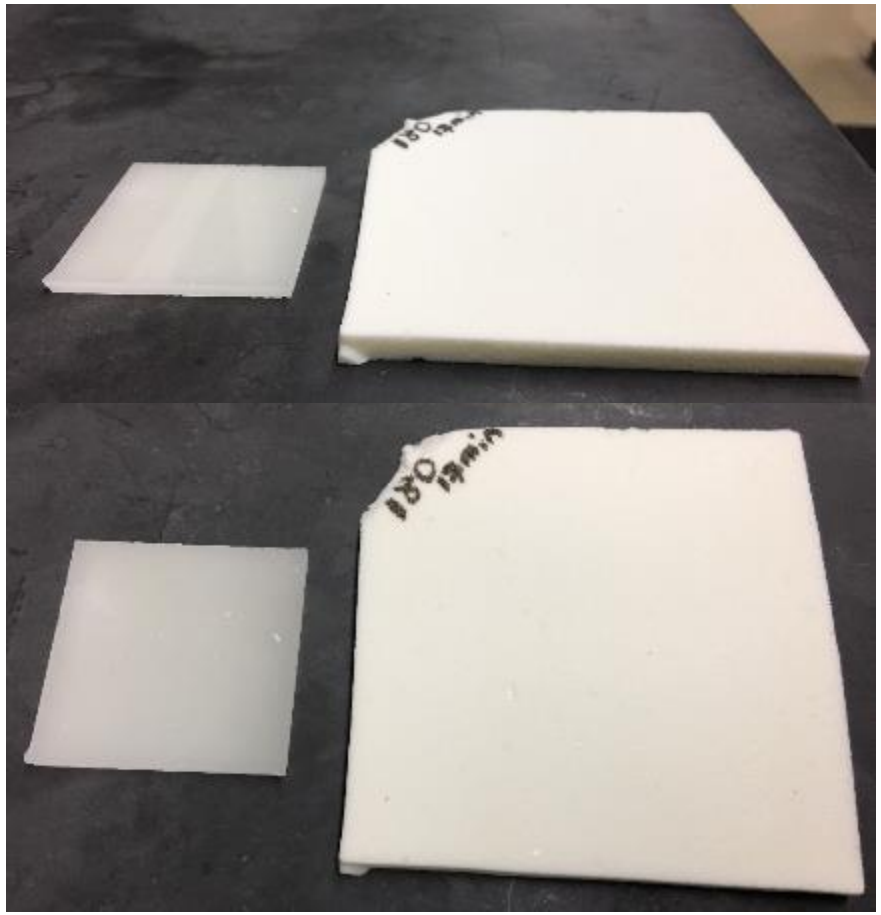
Expandable polymeric microspheres are more efficient in reducing composite density

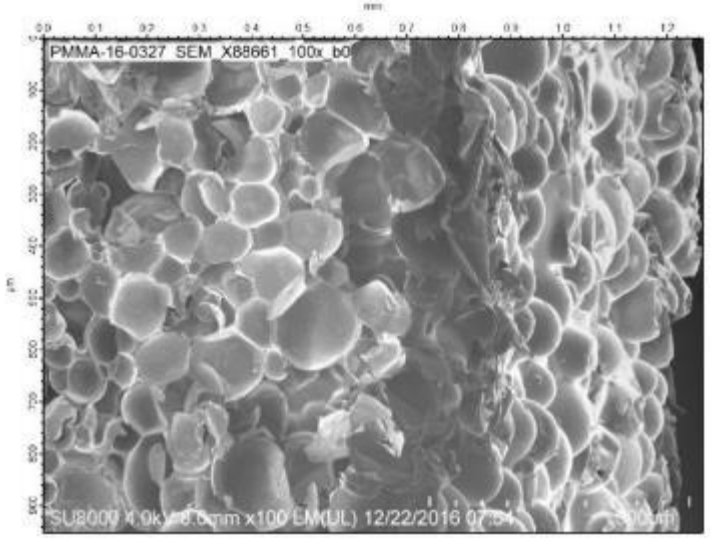


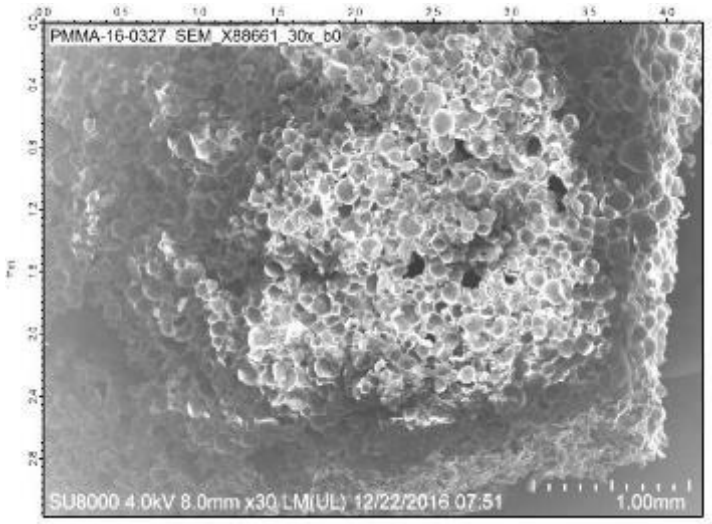
Expandable microspheres in neat resin

- Larger microspheres → higher efficiency
- 90% density reduction with 7-10 wt% microspheres

Cast acrylic







Summary

- **LOW VISCOSITY** at room temperature for excellent fiber impregnation
- **THERMOFORMABLE** at low temperature
- **LIGHT-WEIGHTING** can be done efficiently with expandable microspheres
- **REACTIVITY** adjustable with temperature to meet processing needs
- **EXISTING PROCESSES** with short molding time
- **BETTER MODULUS** than other thermoplastics
- **GLOBAL SOURCING** – production in 3 world regions by end of 2019

LIQUID THERMOPLASTIC RESIN
with outstanding performance

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