# Carbon Fiber Sheet Moulding Compound: High Performance Delivered at Industry Scale

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# Astar

The European company Astar is specialized in formulating and manufacturing SMC, BMC and CSMC thermoset compounds for moulders and OEMs. Astar has been developing custom-made formulations for more than 55 years in order to deliver high quality solutions for each specific application and end market.

# ASTAR's production plants

2 automated SMC lines
Max. Capacity: 27.000 TN/year
**SMC PRODUCTION**

1 NEW dedicated Carbon Fibre SMC line
Max. Capacity: 5.000 TN/year
**CSMC PRODUCTION**

**BMC PRODUCTION**


**R&D CENTRE**

2 automated BMC lines
Max. Capacity: 8.000 TN/year

1 SMC / CSMC pilot machine
1 BMC / CBMC pilot machine
2 compression presses
1 injection machine

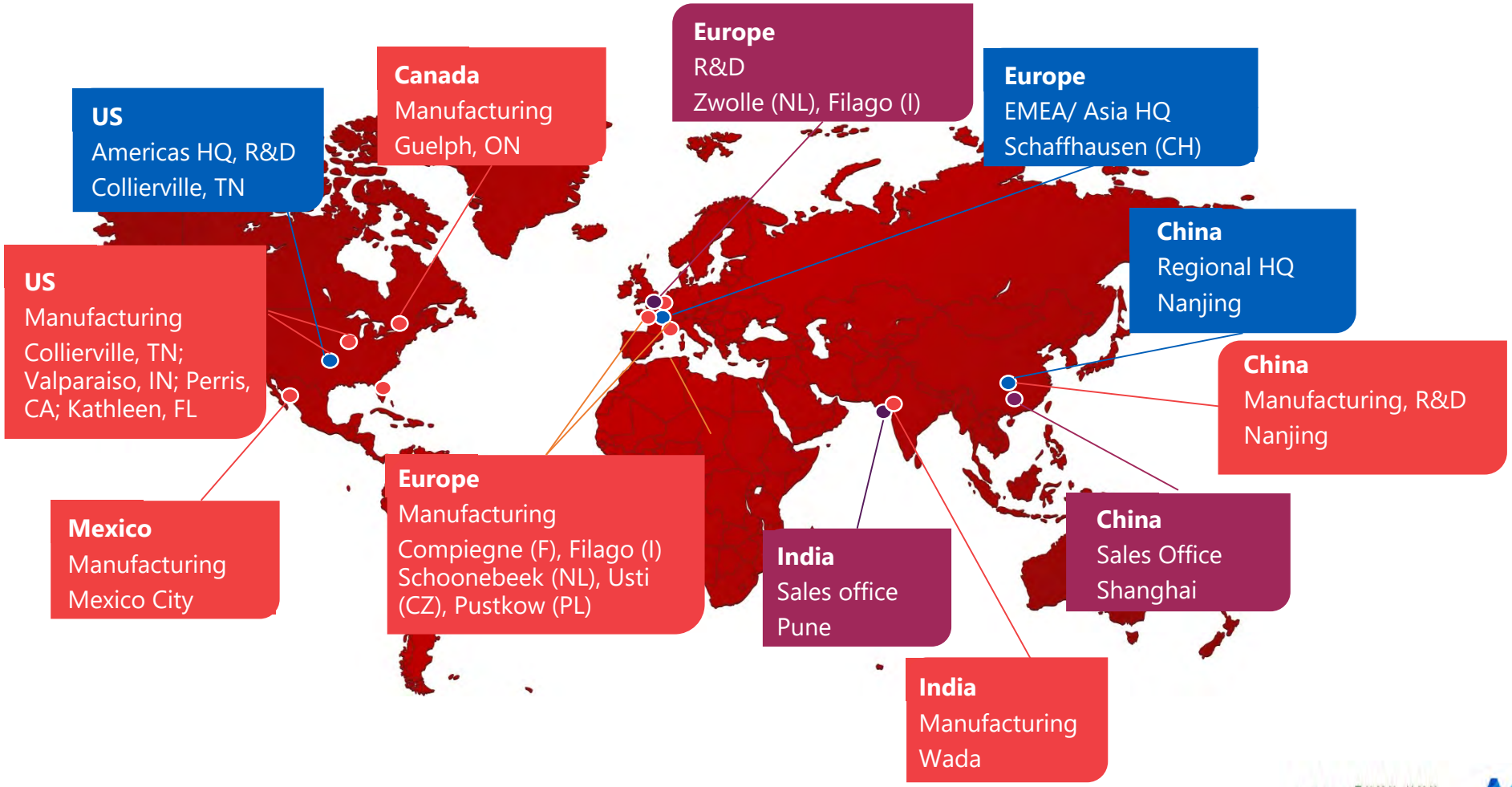
astar AOC Trusted Solutions ZOLTEK Toray Group

# AOC is the leading global supplier of resins, gelcoats and specialty materials for the composites industry

Transportation, Industrial, CIPP/Relining, Wind, Consumer, Building & Infrastructure, Marine


astar AOC Trusted Solutions ZOLTEK Toray Group

# Supporting Our Customers Around the World



# Zoltek Corporate Profile

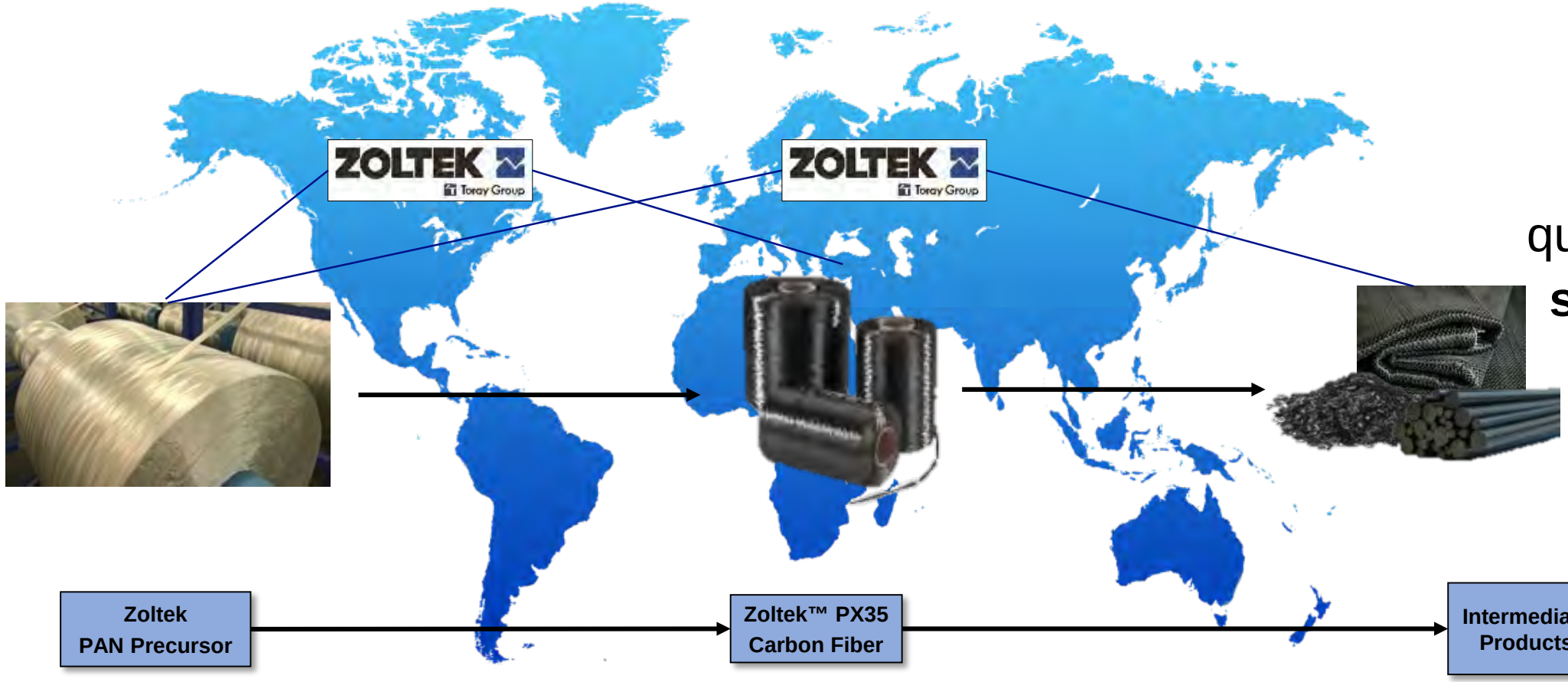
- Company Name: Zoltek Companies, Inc.
- Founded: 1975
- Headquarters: St. Louis, MO, United States
- 100% subsidiary of Toray Group
- Representative: Nobuya Ando (CEO, COO & President)
- Group Companies: 3 Consolidated Subsidiaries
- Employees: 2,300


**Zoltek PX35 50k Carbon Fiber**

- 50K Filament
- Manufactured from PAN Precursor
- DNV-GL Approved
- Processing Support Available
- Spool to Spool Consistency

| Property | SI | US |
|---|---|---|
| Tensile Strength | 4,137 MPa | 600 ksi |
| Tensile Modulus | 242 GPa | 35 msi |
| Elongation | 1.64% | |
| Density | 1.81 g/cc | 0.065 lb/in$^3$ |
| Fiber Diameter | 7.2µm | 0.283 mils |

# Zoltek's Carbon Fiber Plants




**One Zoltek PX35 50k** carbon fiber quality from **two separate**, **fully integrated locations**: Hungary and Mexico

ZOLTEK Toray Group

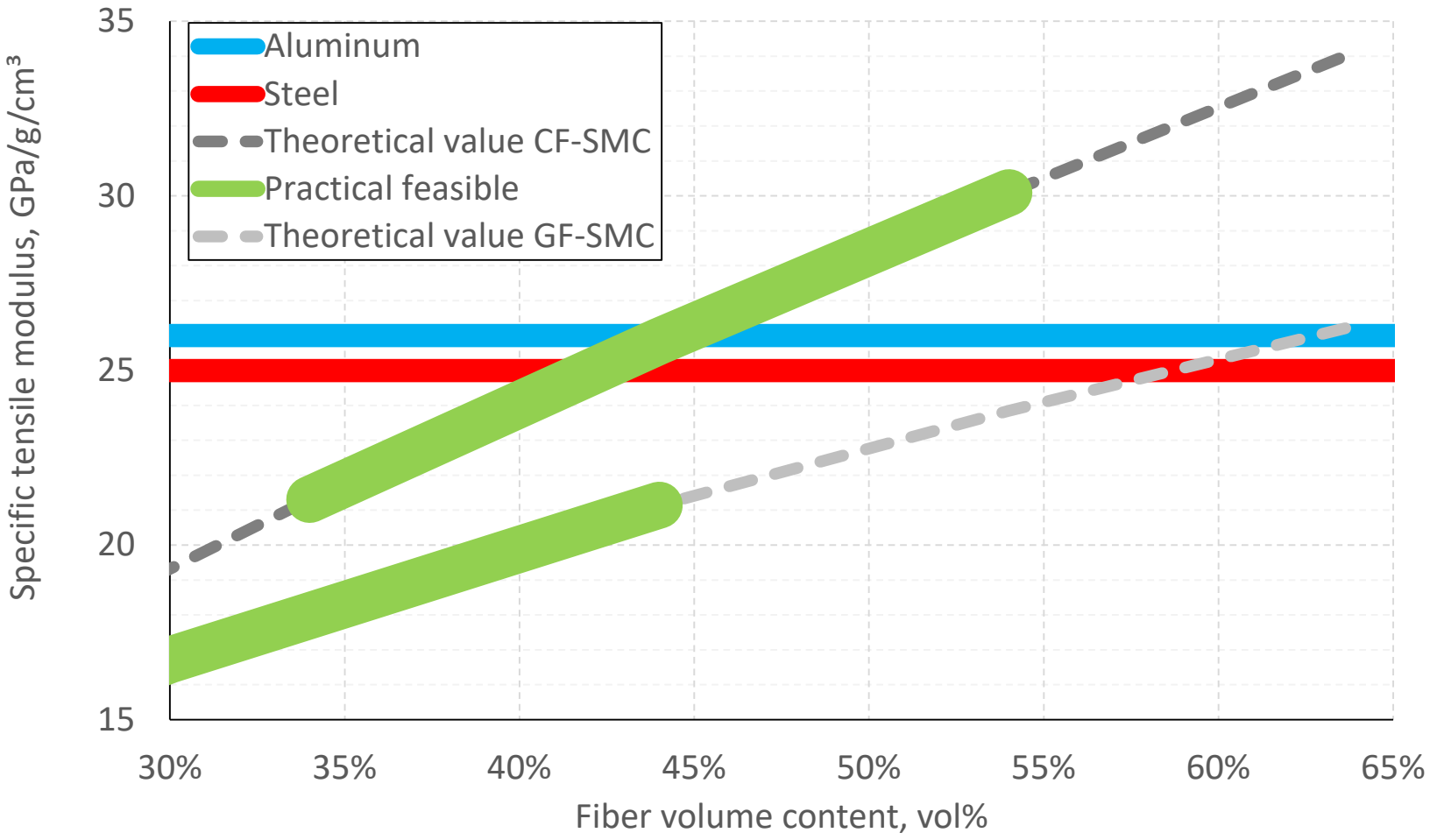
CONSOLIDATED SUPPLY CHAIN

astar AOC Trusted Solutions ZOLTEK Toray Group

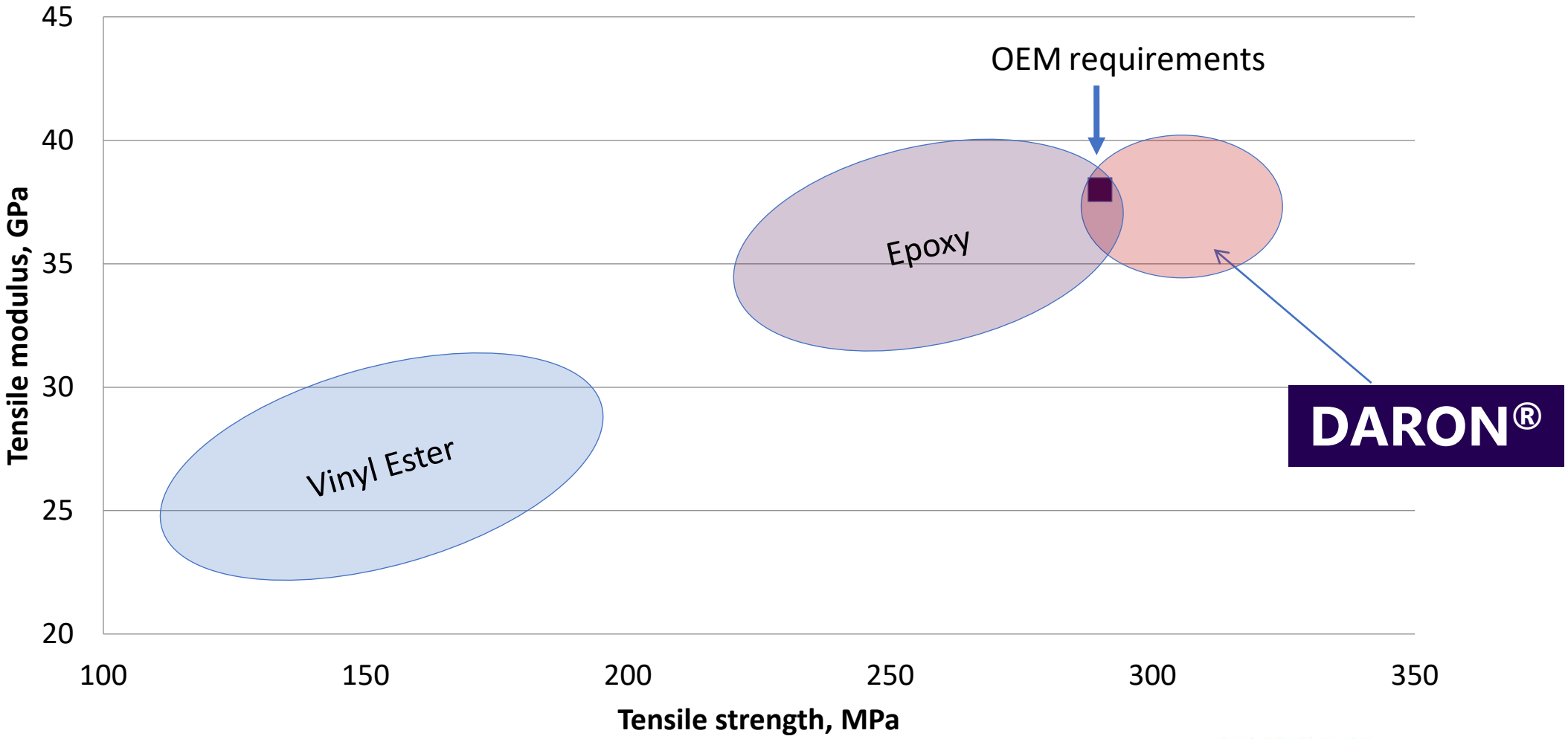
# Materials

# Carbon provides biggest weight saving but cost is a challenge

# CF-SMC offers the highest specific stiffness

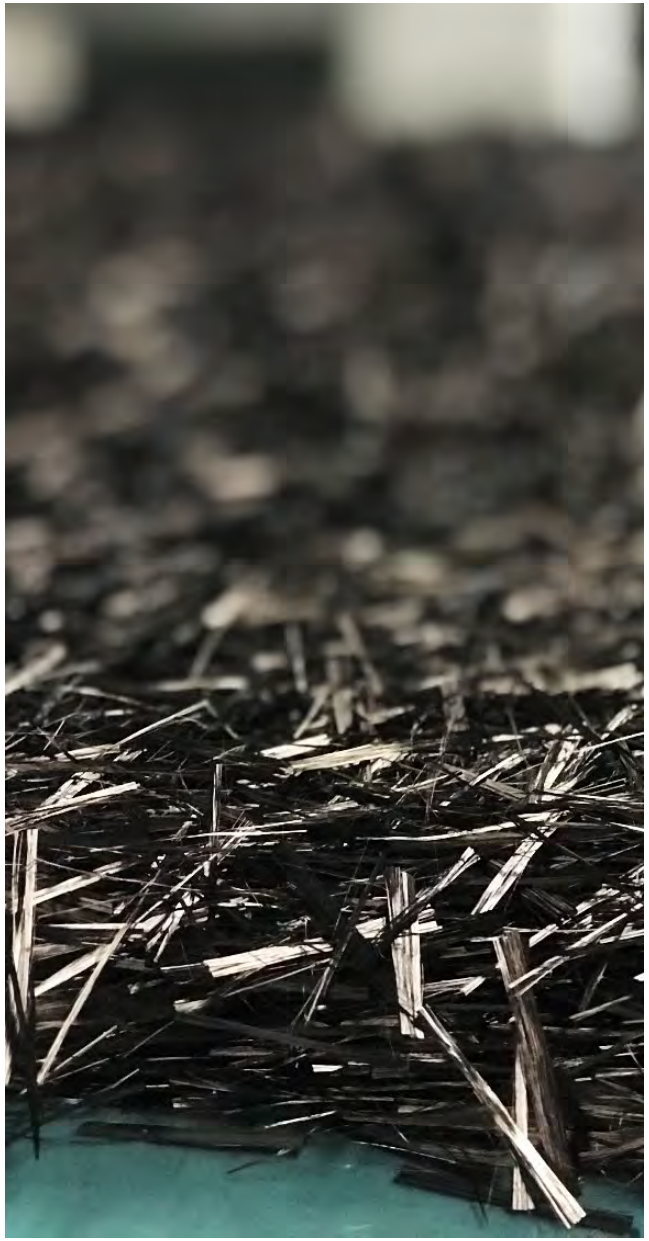


# Daron ® gives the highest combination of strength and stiffness



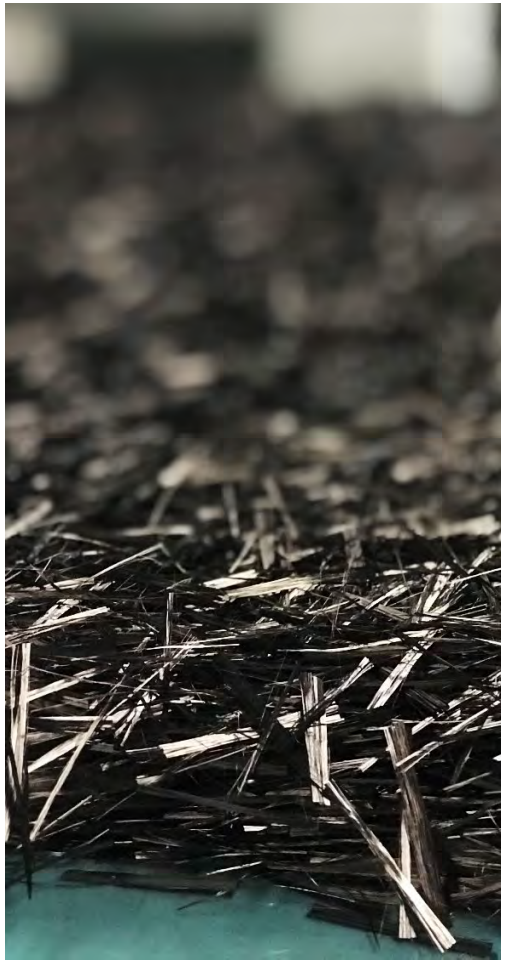
# CSMC Opportunities

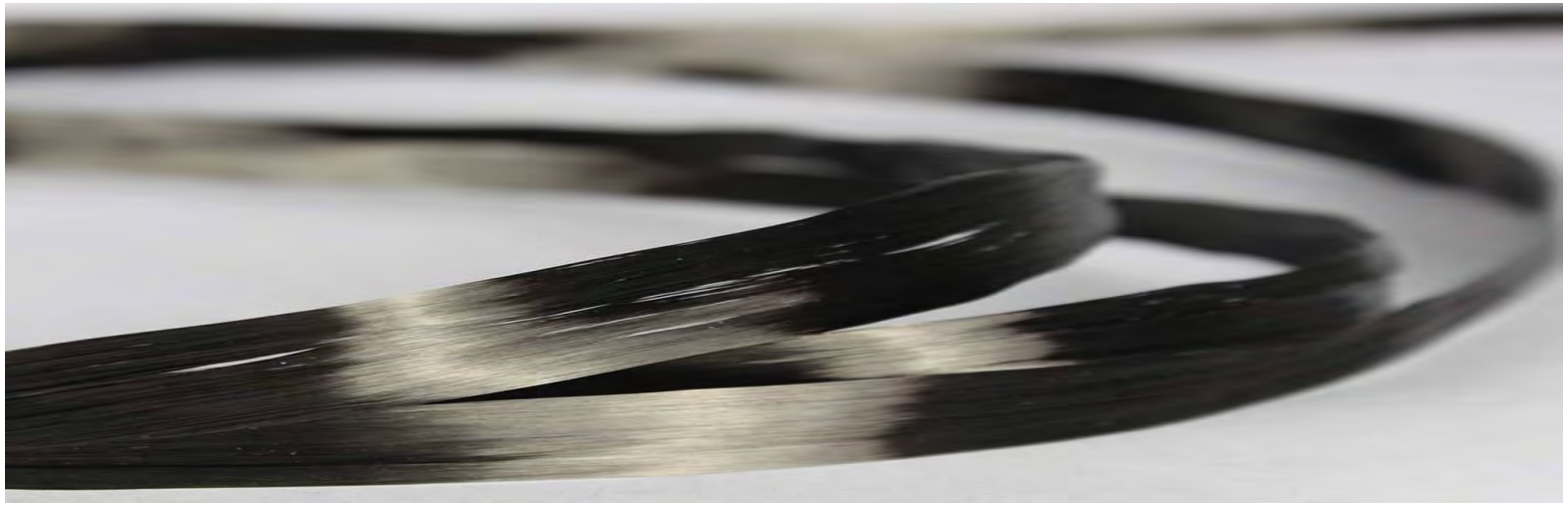
- Relatively new technology
- Growing interest from OEMs
- Replacement of other materials to save weight
- Low price compared to other carbon fibre composites



# Cost Reduction

- Automation
- Continuous Production
- Innovative CSMC based on split 50K carbon fiber
- Price of 50K fibre
- Performance of 3K fibre

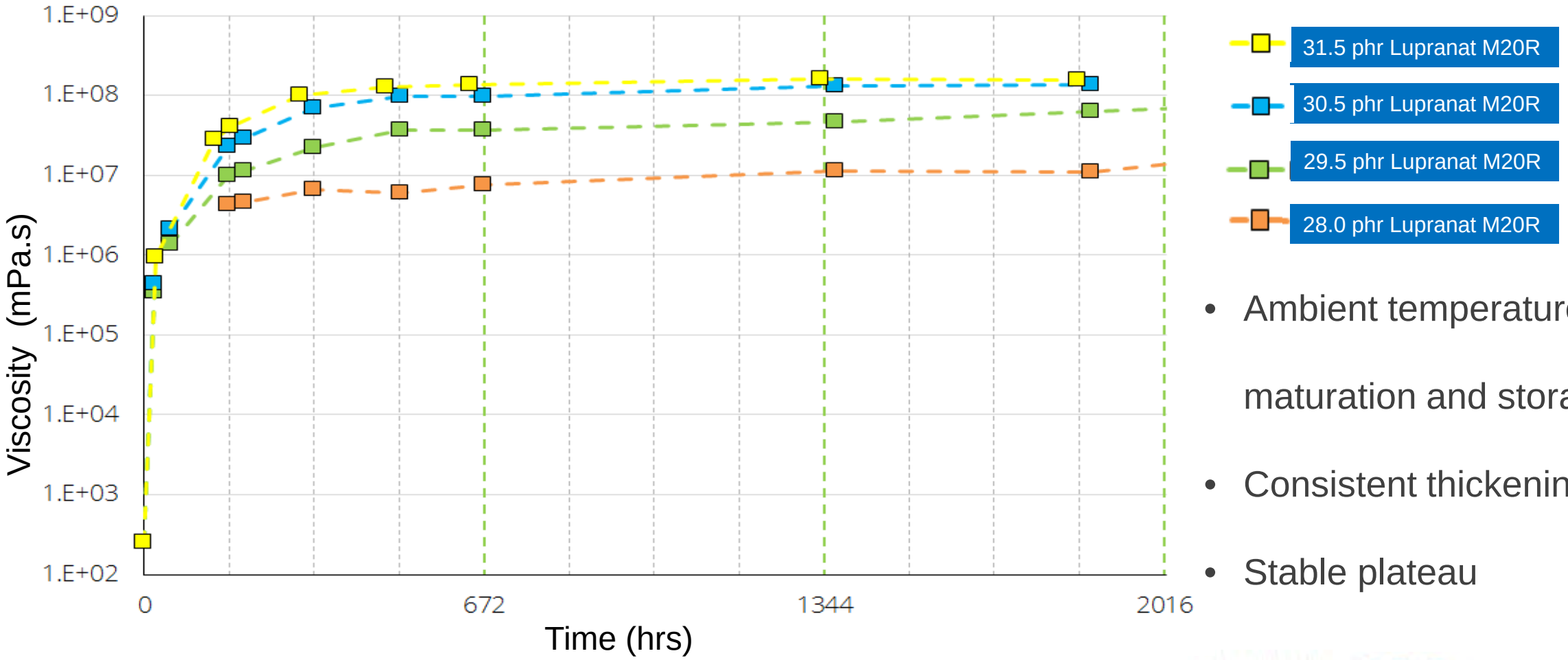




# Daron® 8151 for SMC

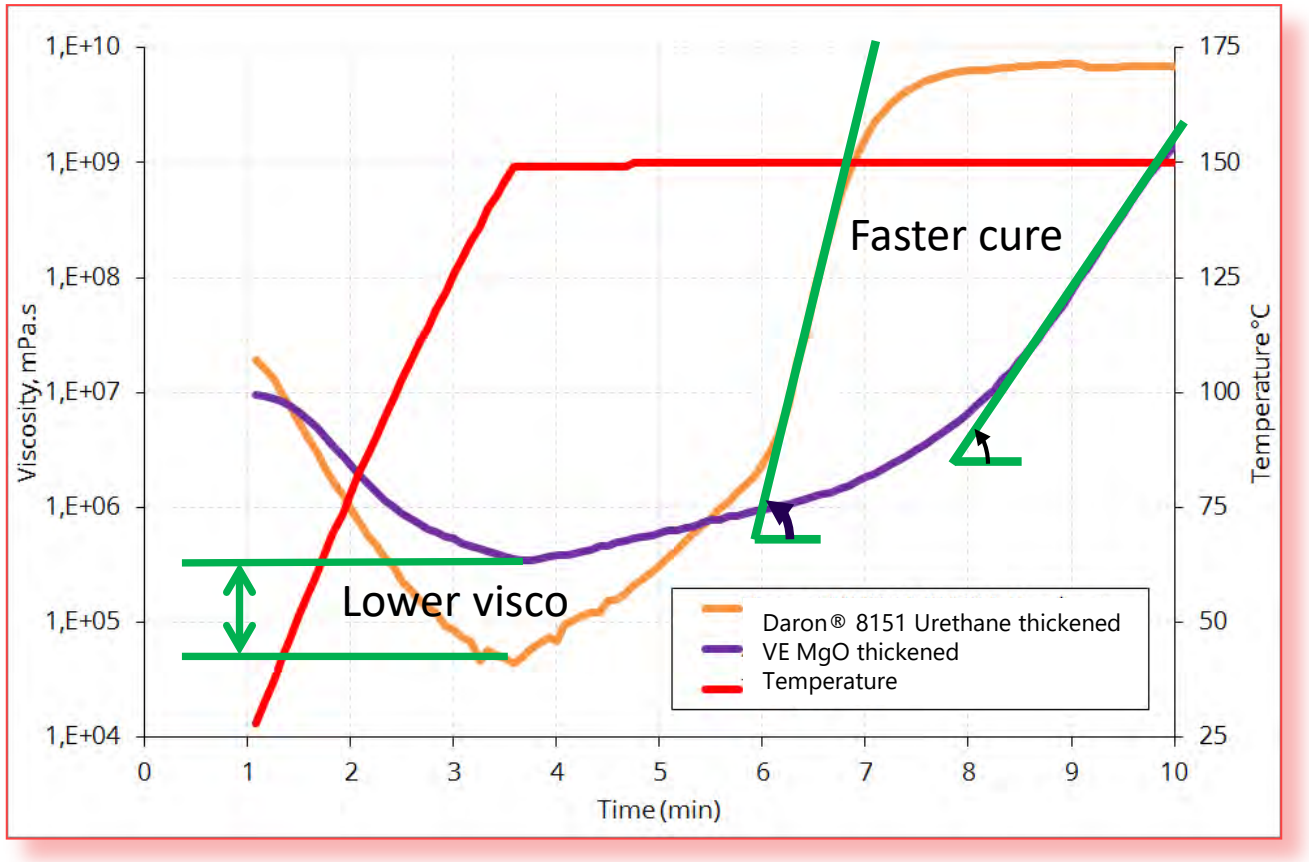
- Low viscosity enabling high fiber content
- Smell friendly compound
- Robust ambient temperature processing at all steps
- Tuneable thickening and flow
- High strength and stiffness
- Ultralow emissions and smell enable interior parts

# Daron® thickening plateau is Tunable through NCO index



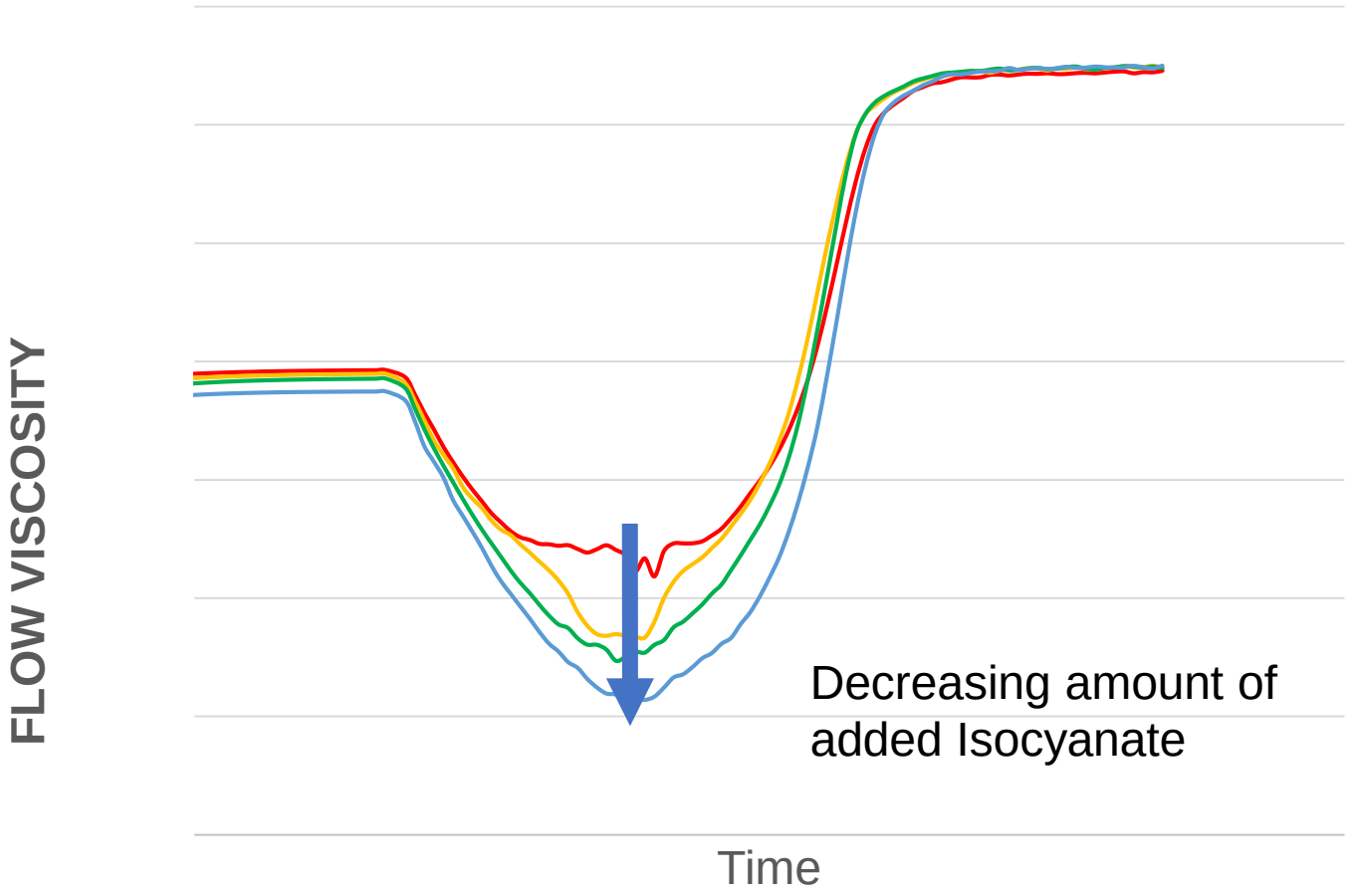

- Ambient temperature maturation and storage
- Consistent thickening
- Stable plateau

# Excellent Material Flow and Faster Curing




- Daron® 8151 gives lower flow viscosity than MgO thickened Vinylester compounds
- Yet, fibers are transported well
- Cure of Daron® 8151 is faster than MgO thickened Vinylester

# SO MOLDING VISCOSITY CAN BE TUNED




Flow viscosity can be tuned for

your specific part complexity

via the isocyanate amount used

# Carbon Tow Technology

<u>The most suitable Carbon Fiber tow must contain</u>

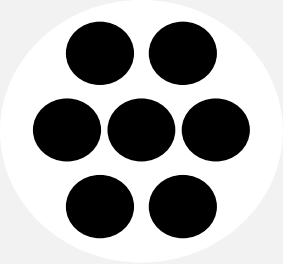
- Right Sizing Chemistry
- Right Sizing Content
- Right Winding

Sizings are available for the following resin classes:

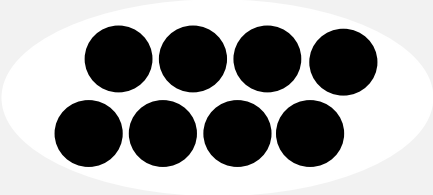
| Thermoplastics | Thermosets |
|---|---|
| Polypropylene | Epoxy |
| Polyamide | Vinyl ester |
| High Temperature Thermoplastics | Polyester |
| | Polyurethane |

# Several Tow Formats

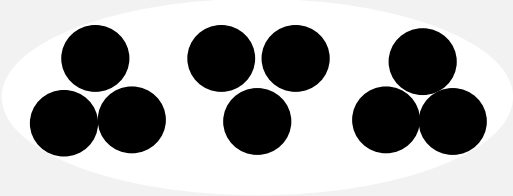
| | Standard | Spreadable | Split |
|---|---|---|---|
| Shape | Conical (Rope-like) | Wide & Flat | Split to 3k strands |
| Product Code | PX3505015**T**-13 | PX3505015**W**-13 | PX3505015**K**-13 |
| Spread | Not spreadaple | 22-25 mm | >20mm with several strands |
| Twists | Twisted | No Twist | No Twist |
| Application | High AW fabrics | Low AW fabrics (150-300 gsm) | SMC |



**Standard tow shape, rope style**



**Spreadable tow shape, wide and flat**



**Split tow with 3k substrands**

# Sheet Molding Compound - SMC

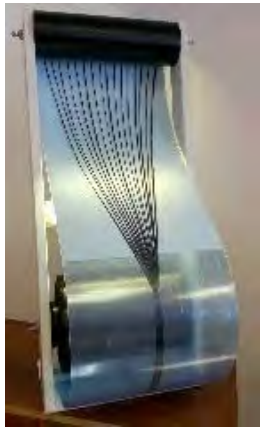
**ZOLTEK™ Split Fiber PX35 K for Sheet Molding Compound**

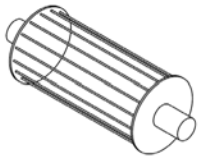
**Zoltek PX35 50k**

Chopping

**50k chopped fibers**

**Zoltek PX35 50k KASSEN**
Pre-split to 3k substrands





Chopping & separating

**3k chopped fibers**

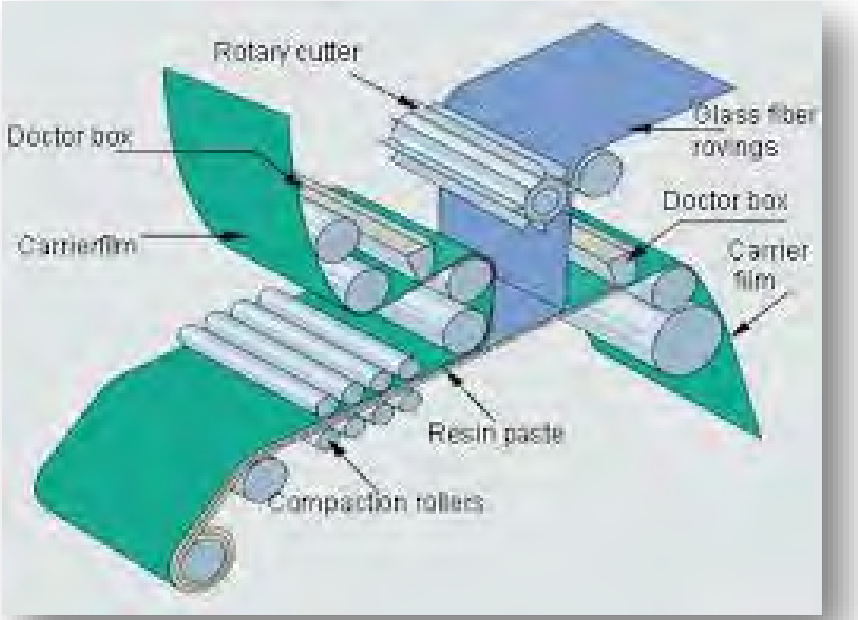
# Process

# SMC Process

## Standard SMC conditions

**Standard Processing Conditions**

- Processing at ambient temperature
- Maturation at room temperature (controlled conditions)
- Storage and transportation at ambient conditions




**Standard SMC** line at room temperature

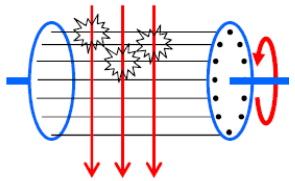
**Adapted to carbon fiber**

- Fiber feeding is optimized for carbon fiber
- Resin and fiber impregnation is optimized for high fiber content
- Typically no fillers are added

# Picker/Dispersion Roll

There are two main types of Dispersion Rolls

**Wire type**

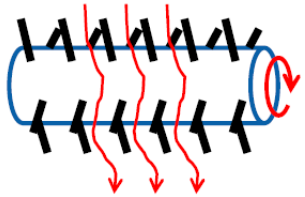


**16 Wires/Lap to disperse CF**

**All bundles of CF fall down after hitting wire**
**→CF dispersion is stable**

**Best:** A wire type dispersion roll. Result is good and stable dispersion.

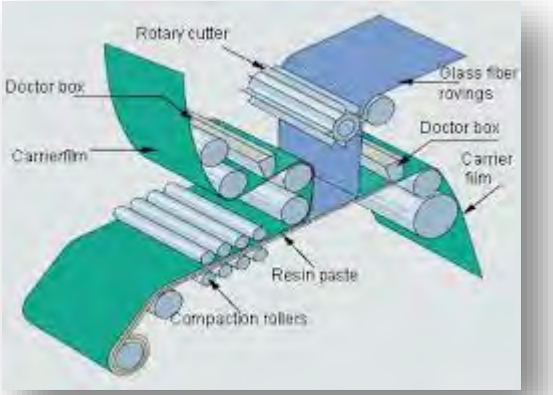
**Needle type**



**4 Needles/Lap to disperse CF**

**Some bundles of CF fall down without hitting needles**
**→CF dispersion is unstable**

**OK:** A needle type dispersion roll. But, may result in unstable dispersion




No Dispersion/ Picker Roll

**Worse:** No Dispersion roll under the chopper.

# Split 50K Fiber vs 12K Fiber

12k carbon fiber

50k carbon fiber split to 3k

12k carbon fiber

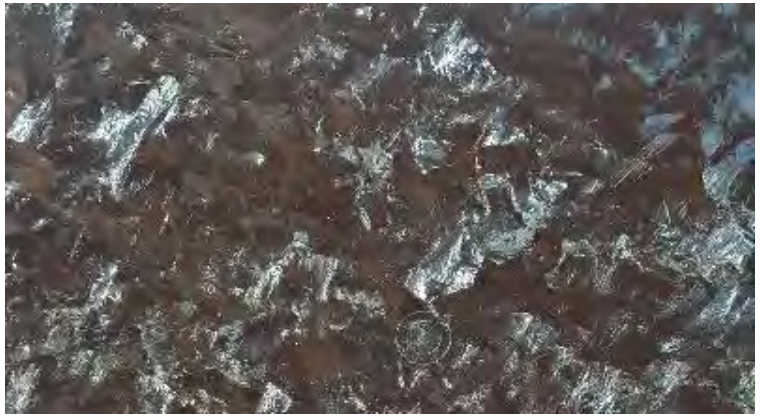
50k carbon fiber split to 3k

# Results

# Sheet Moulding Compound – SMC

## Standard PX35 50k tow

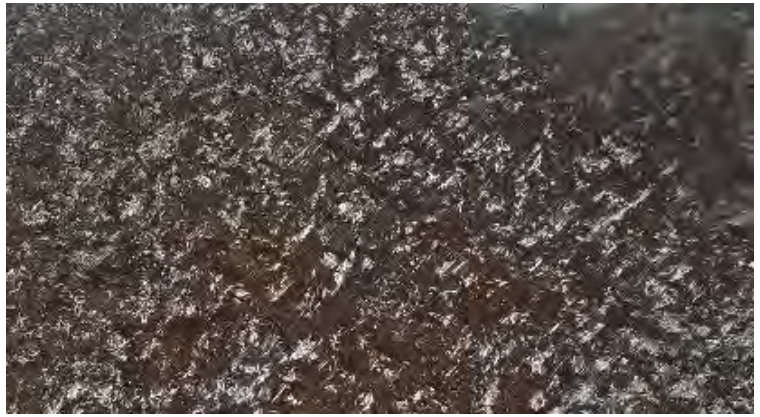
- Large tow with 50k filaments
- Suitable for SMC
- Available with several sizings for Polyester resin, Epoxy resin, Vinylester resin



Zoltek PX35 50k

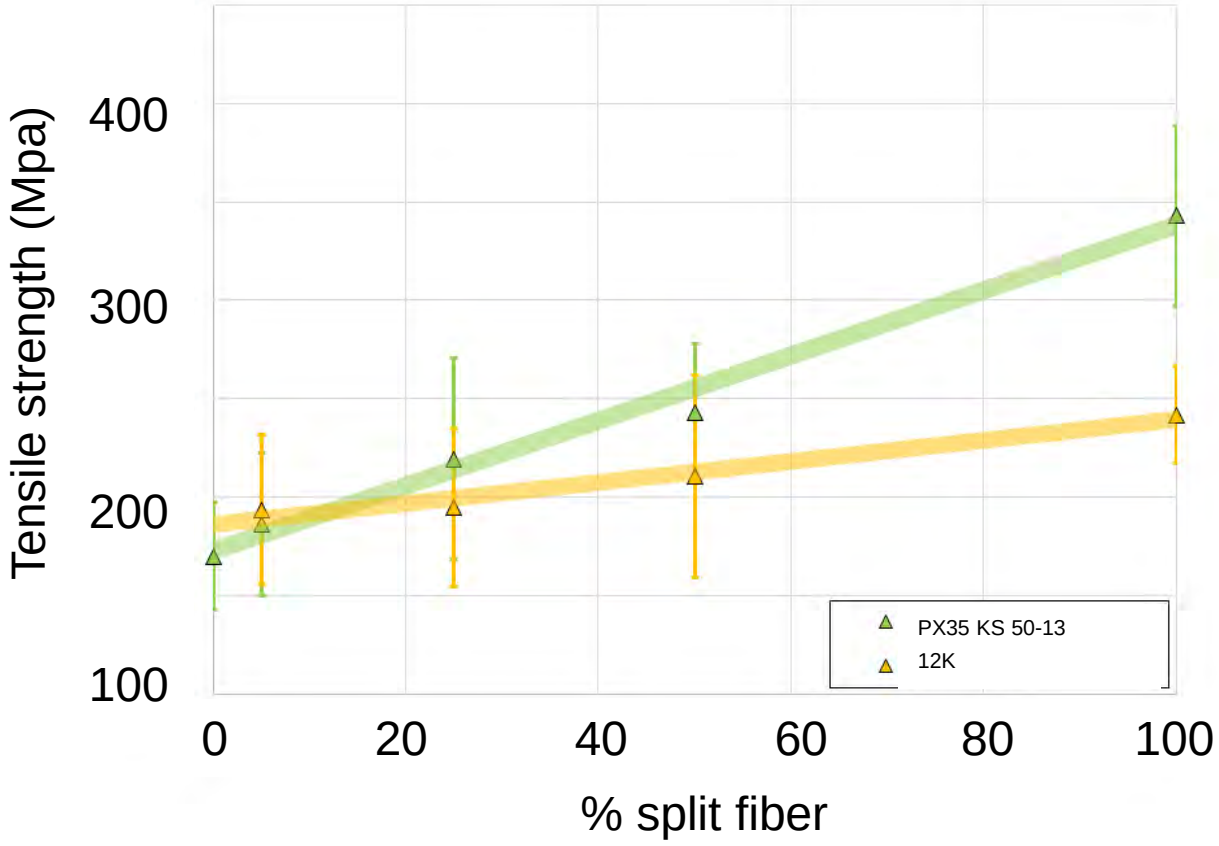
## PX35 KS tow

- Based on Zoltek PX35 50k tow
- Falls apart into 3k strands after chopping
- Can be processed in standard SMC sheet machines



Zoltek PX35 KS (split tow 3k)

# Splitting up Fiber Tow Increases Tensile Strength Considerably



# 12K vs 50K Splitted Mechanical Performance

## Industrial Scale Results

### VE CSMC 50% Wf

| FIBRE | TENSILE MODULUS | TENSILE STRENGTH |
|---|---|---|
| 12K | 27000 | 150 |
| 50K splitted | 30000 | 240 |

| FIBRE | FLEXURAL MODULUS | FLEXURAL STRENGTH |
|---|---|---|
| 12K | 25000 | 250 |
| 50K splitted | 27000 | 330 |

# Superior Mechanical Properties

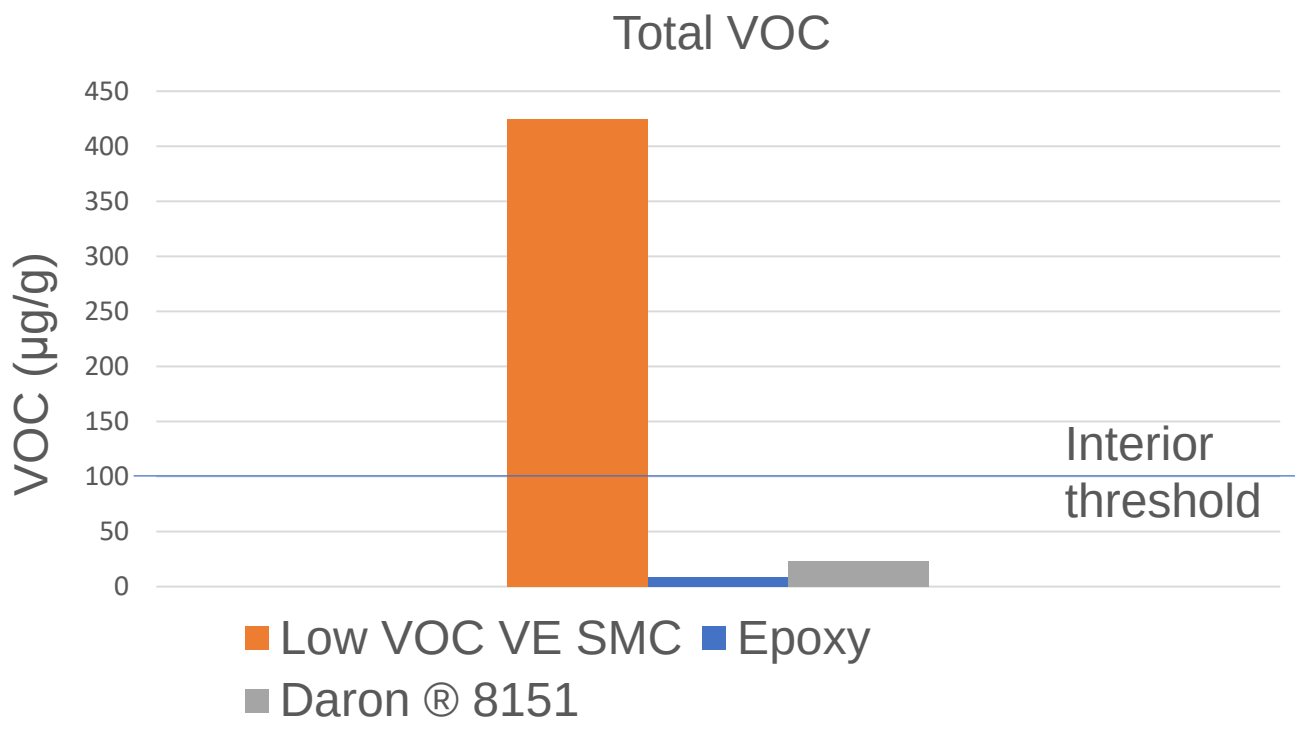
## Industrial Scale Results

### Daron 8151 CSMC 57% Wf

| FIBRE | TENSILE MODULUS | TENSILE STRENGTH |
|---|---|---|
| 50K splitted | 36000 | 325 |

| MATERIAL | FLEXURAL MODULUS | FLEXURAL STRENGTH |
|---|---|---|
| 50K splitted | 30500 | 460 |

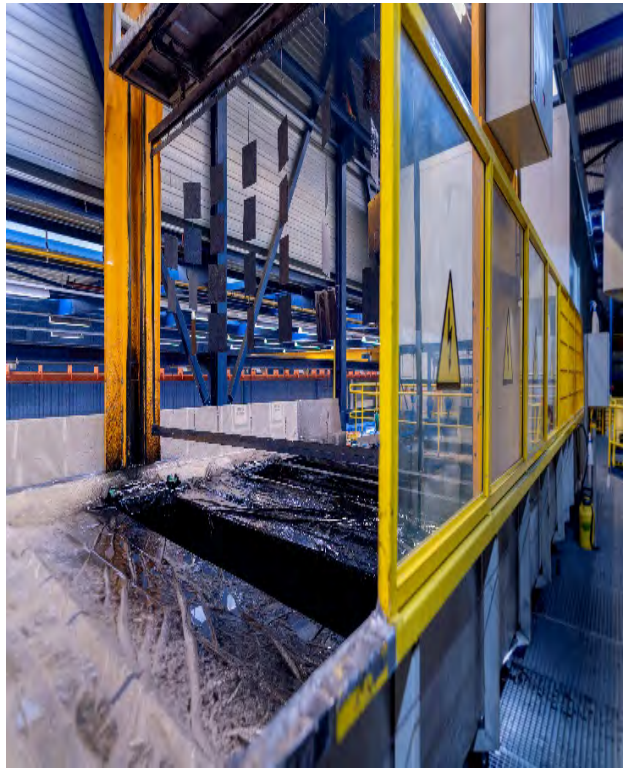
# Very Low Smell and Emission (No Styrene) from Molded Parts




| | Daron® 8151 |
|---|---|
| Total VOC (VDA 278) | 23 |
| Smell (VDA 270) | 3 |

Source Daron® 8151 : IMAT-UVE
Molded for 1 min/mm @ 145°C, No Post-Treatment
Method: VDA 278 Thermodesorption
Source Low VOC VE SMC: presentation Ashland at SPE ACCE 2016
Source Epoxy: Presentation Hexion at JEC conference 2017

# SMC based on Daron® 8151 is E-Coat Compatible



E-coat bath

Oven (30 min at 210°C)

No delaminations

# Summary

# Summary

- ✓ Carbon Fiber SMC on full industrial scale
- ✓ Commercially available
- ✓ High Mechanical Performance
- ✓ E-coat ready
- ✓ No VOCs