

# **Carbon Fiber Sheet Moulding Compound: High Performance @ Industrial Grade**

## **GUILLERMO ASTORQUI**

Business Development Manager  
ASTAR S.A.

Sangroniz, 30  
E48150 Sondika  
Bizkaia (Spain)

Tel: +34 944 531 598  
Guillermo.astorqui@astar.es  
www.astar.es

## **LUUK GROENEWOUD**

Strategic Projects Manager  
AOC Nederland B.V.

Ceintuurbaan 5  
Zwolle  
8022AW  
The Netherlands

Mobile: +31683648839  
Office: +31383033110  
luuk.groenewoud@aocresins.com  
www.aocresins.com

## **TOBIAS POTYRA**

Global Automotive Director  
Zoltek Corporation

3101 McKelvey Road  
Bridgeton, MO 63044, USA

Cell Phone: +49 (172) 692 7347  
tobias.potyra@zoltek.com  
www.zoltek.com



# Outline

## 1. Company Introduction

- ASTAR
- AOC
- Zoltek

## 2. Materials

- Resin
- Fiber

## 3. Compounding

- Fiber bed
- Maturation

## 4. Results

- Mechanical Properties
- VOCs
- E-coat ready

## 5. Summary

# Companies

---





# 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**



**BMC PRODUCTION**

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

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



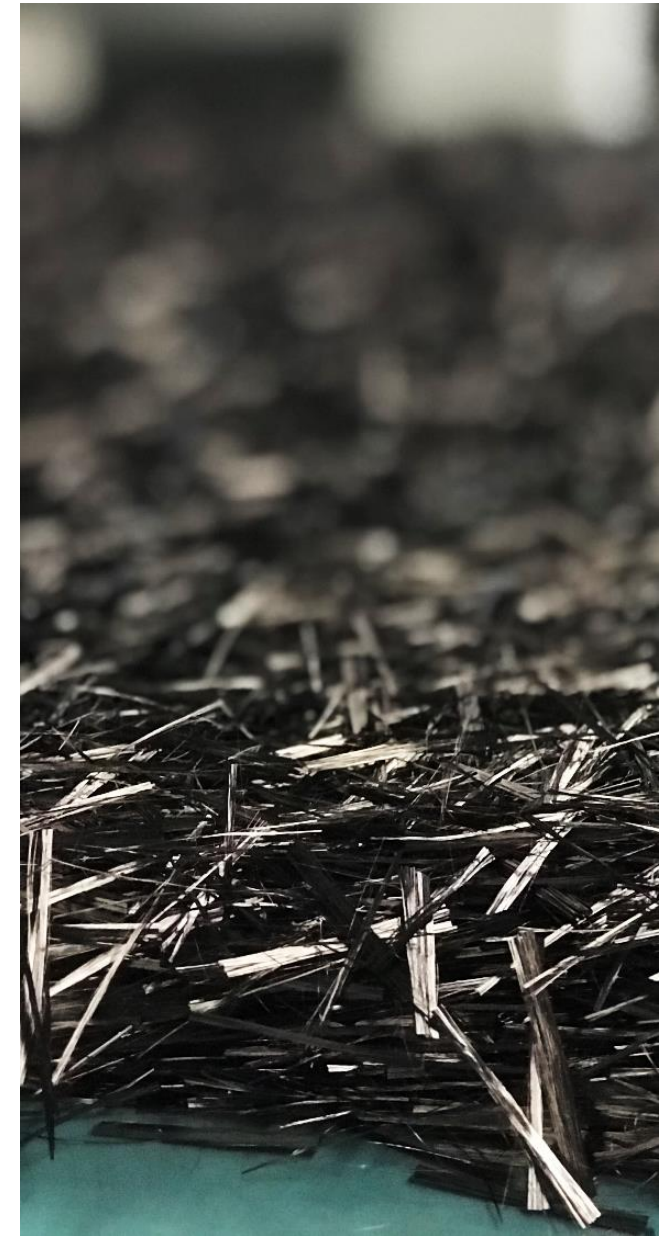
**R&D CENTRE**

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



# CSMC Opportunities

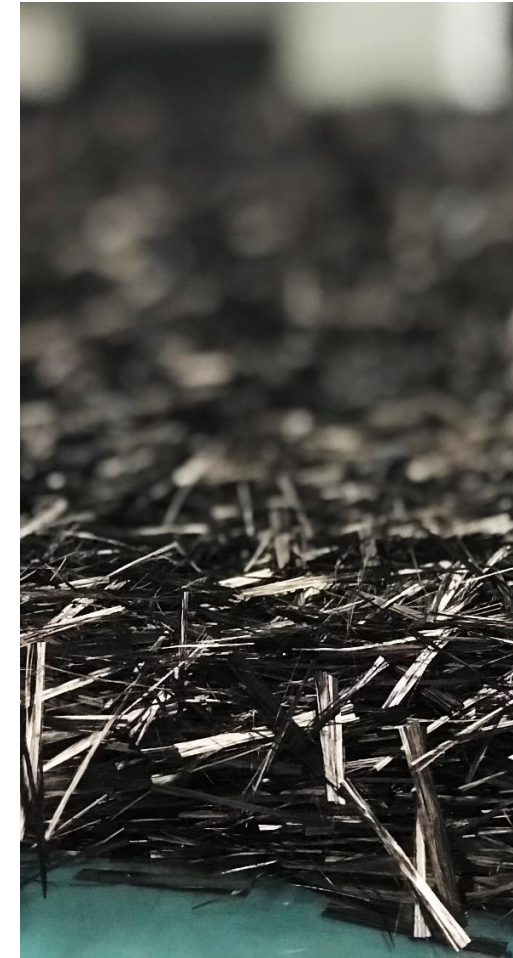
- Relatively new technology
- Growing interest from OEMs
- Replacement of other materials to save weight
- Low price compared to other carbon fibre composites





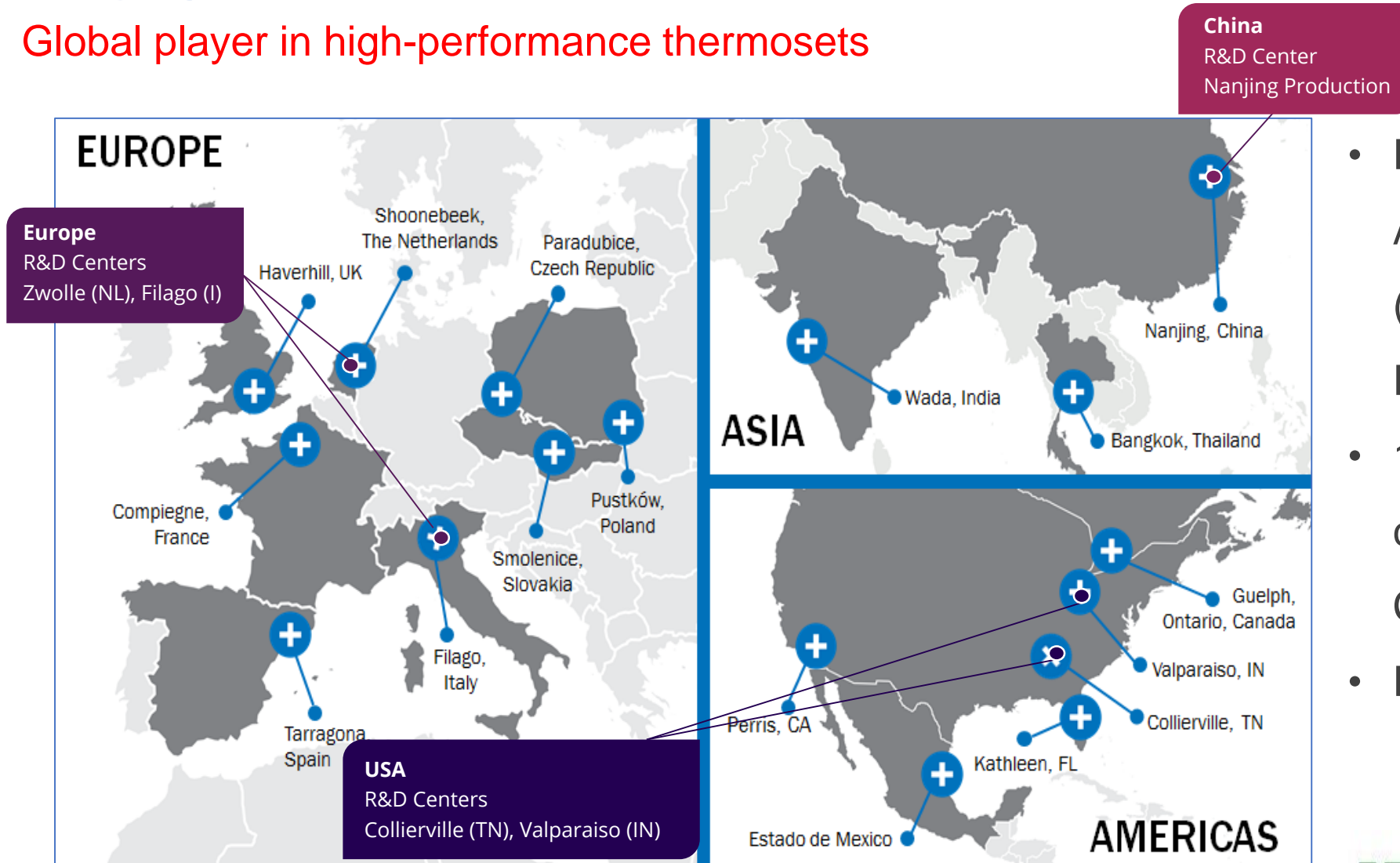
# Cost Reduction

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



# AOC

Global player in high-performance thermosets



- Founded in 2018 out of AOC and Aliancys (former DSM Composite Resins)
- 17 sites globally, 4 R&D centers, HQ in Collierville, TN (USA)
- Employees: 1200



# AOC

## Key markets



- Unsaturated Polyesters and Vinyl esters
- High performance hybrid resins
- Focus on Styrene Free and Carbon Fiber developments

# 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



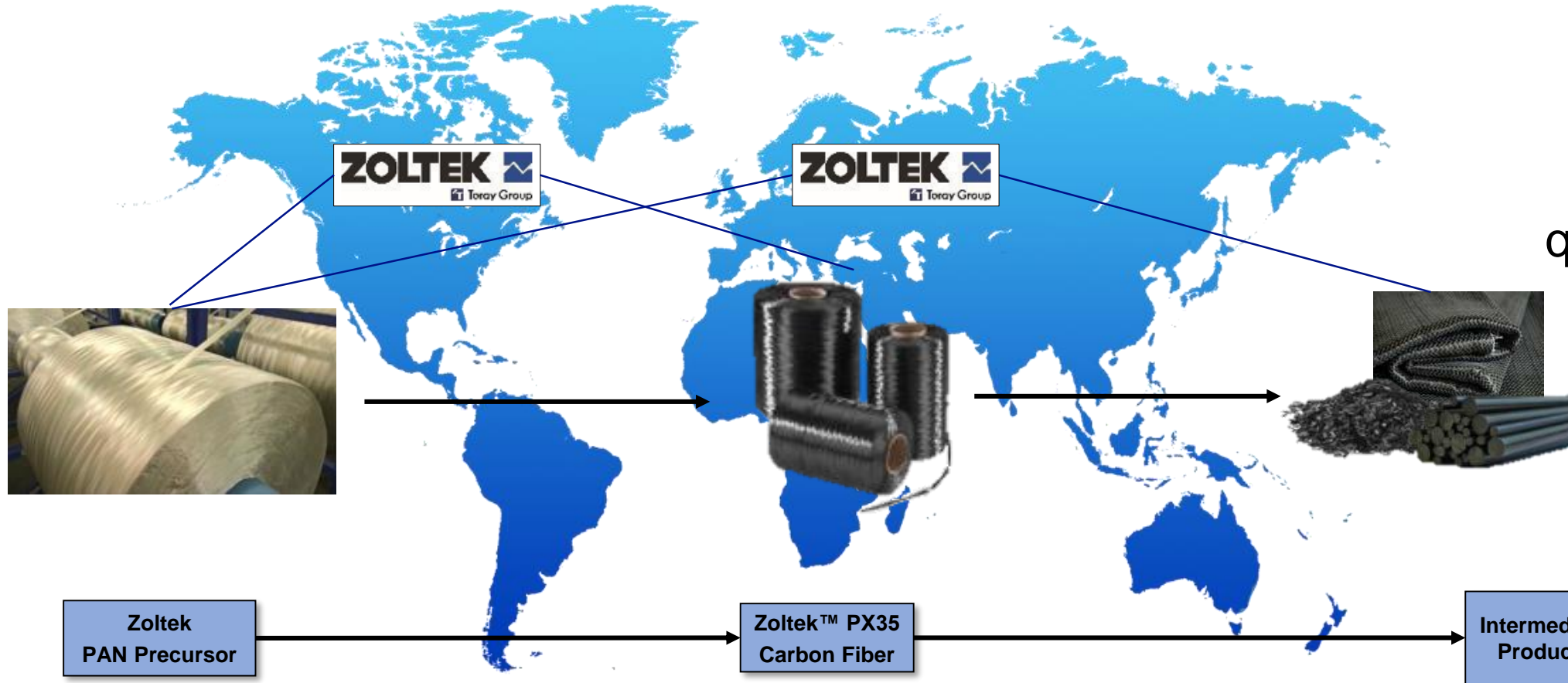
## Zoltek PX35 50k Carbon Fiber

- 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 <sup>3</sup>
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**  **CONSOLIDATED SUPPLY CHAIN**

# Materials

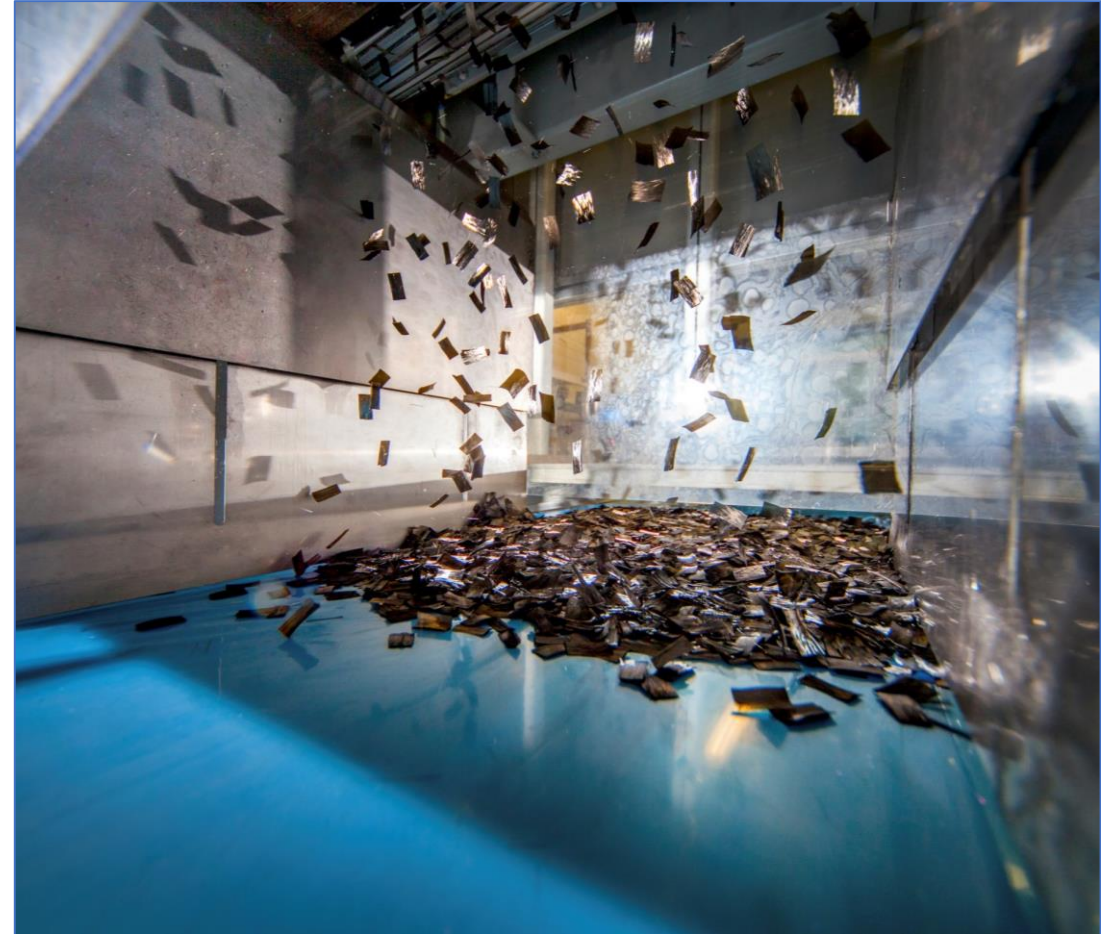
---





# Daron® 8151 for SMC

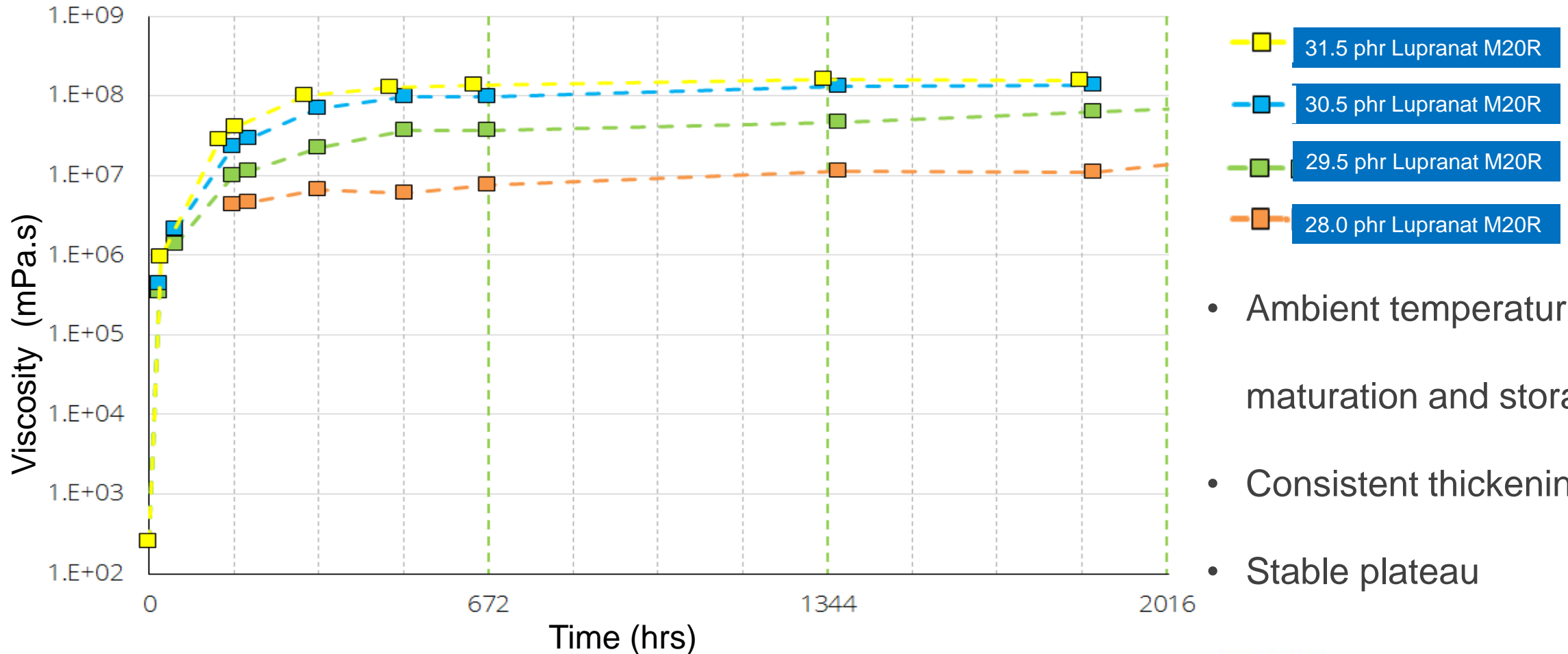
- Low viscosity enabling high fiber content
- Smell friendly compound
- Robust ambient temperature processing at all steps
- Tuneable thickening and flow
- High strength and stiffness
- Ultralow emissions and smell enable interior parts





# Daron® Urethane Thickening

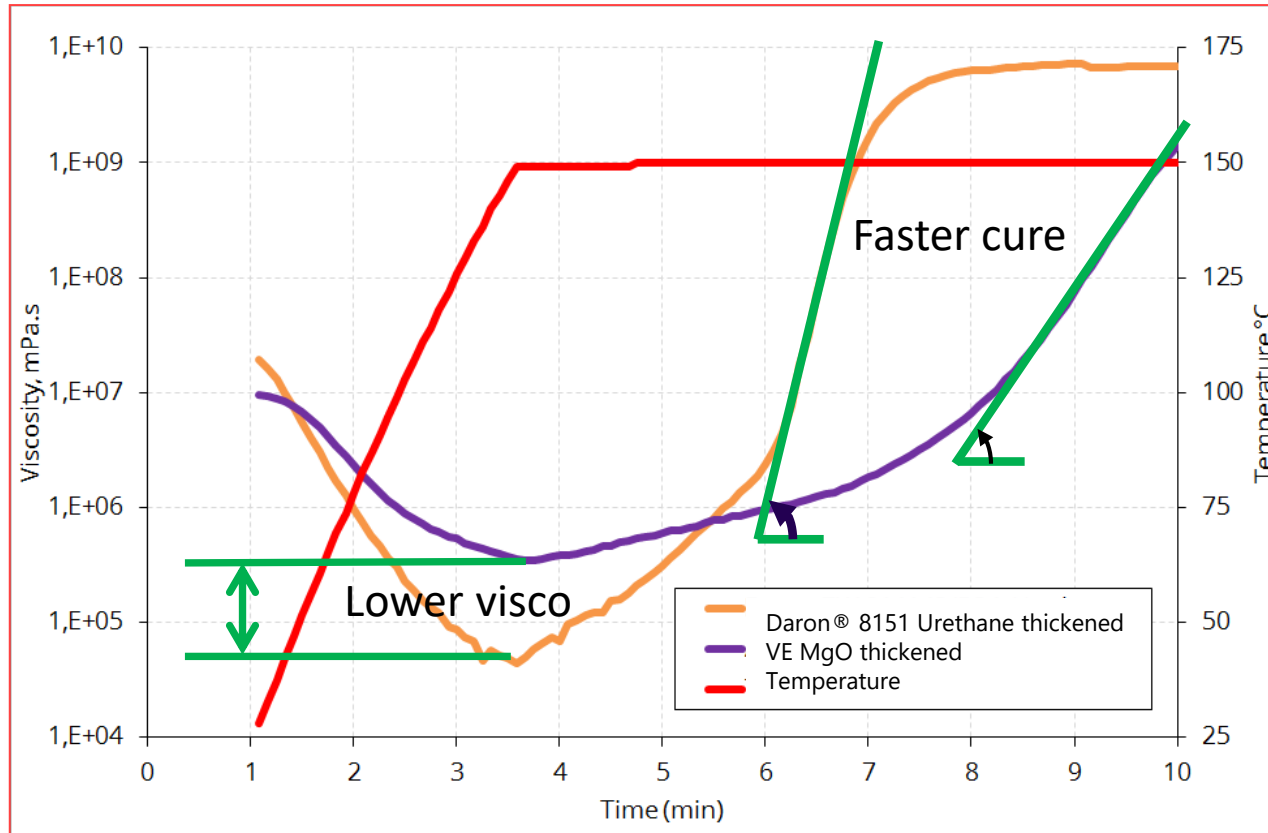
Thickening plateau tunable via amount of isocyanate added



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

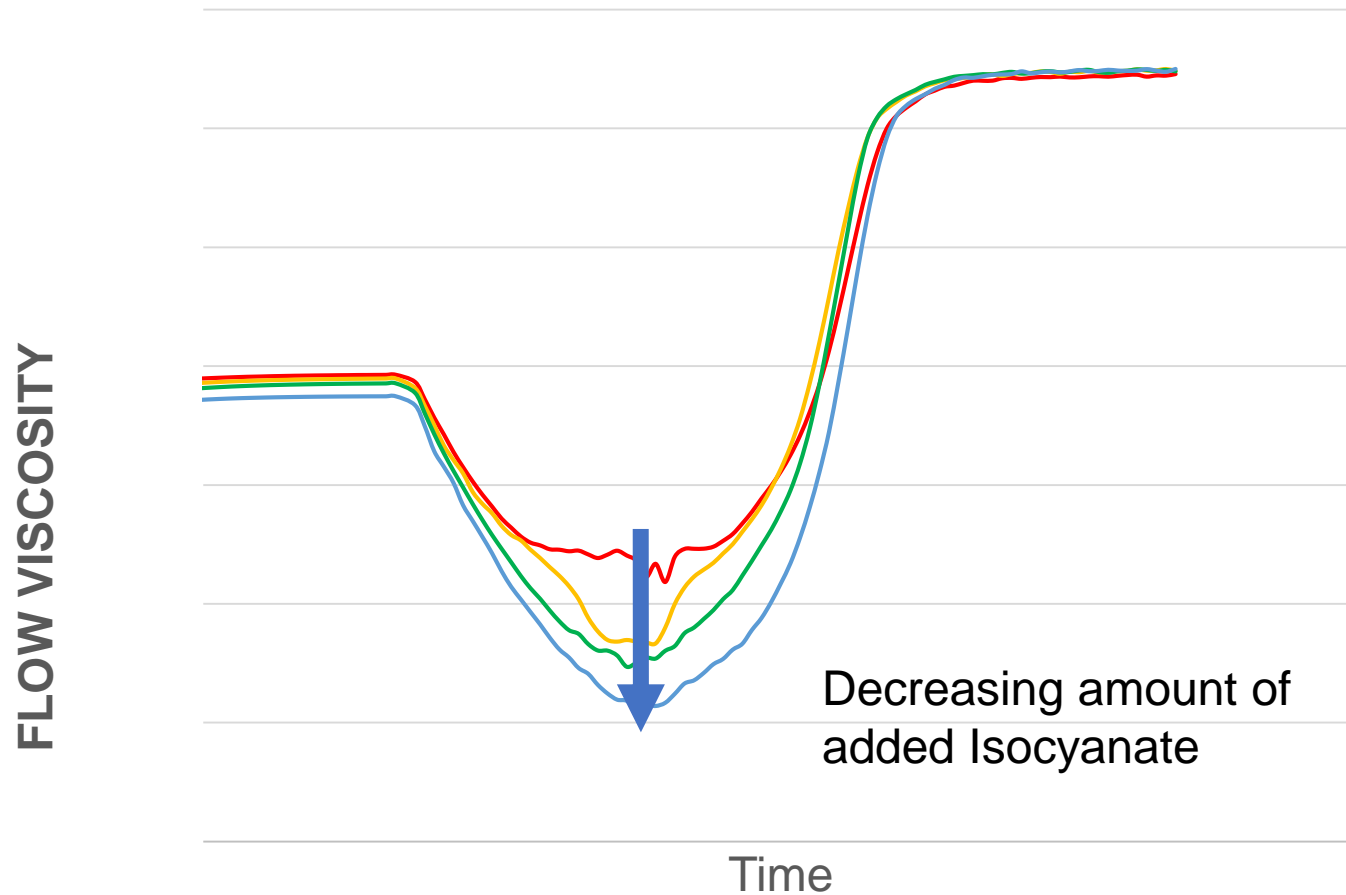
# MOLDING VISCOSITY

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

# MOLDING VISCOSITY CAN BE TUNED



Flow viscosity can be tuned for your specific part complexity via the isocyanate amount used

# Carbon Tow Technology

The most suitable Carbon Fiber tow must contain

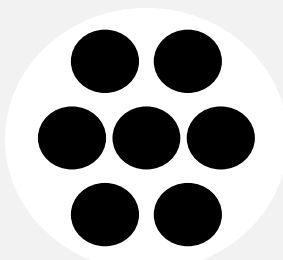
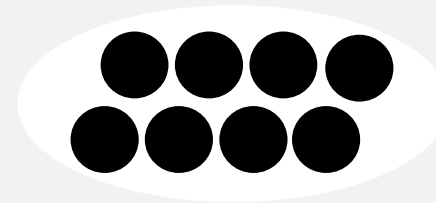
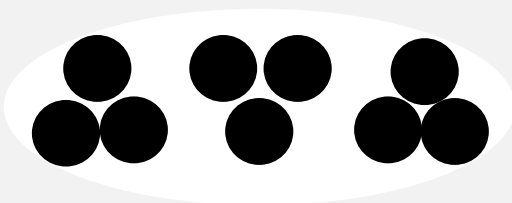
- Right Sizing Chemistry
- Right Sizing Content
- Right Winding

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	PX3505015T-13	PX3505015W-13	PX3505015K-13
Spread	Not spreadable	22-25 mm	>20mm with several strands
Twists	Twisted	No Twist	No Twist
Application	High AW fabrics	Low AW fabrics (150-300 gsm)	SMC
	 <p>Standard tow shape, rope style</p>	 <p>Spreadable tow shape, wide and flat</p>	 <p>Split tow with 3k substrands</p>



# 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

---



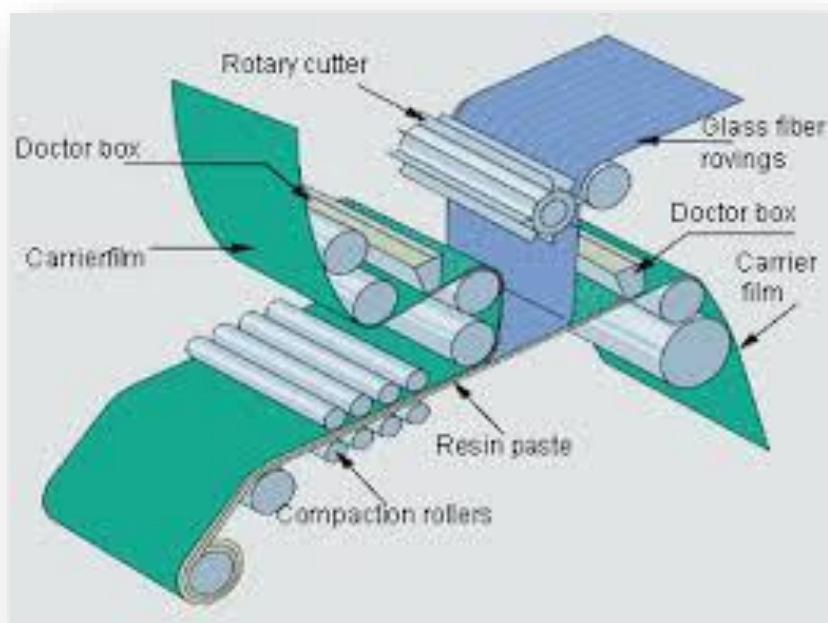
# SMC Process

## 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

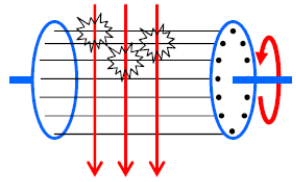
### Adapted to carbon fiber

- 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**

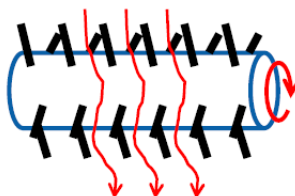


**16 Wires/Lap to disperse CF**

**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.

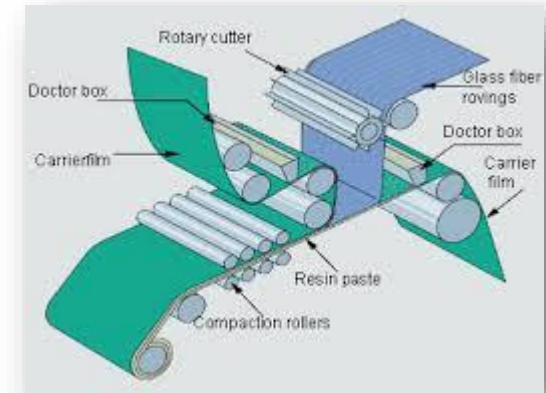
**Needle type**



**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

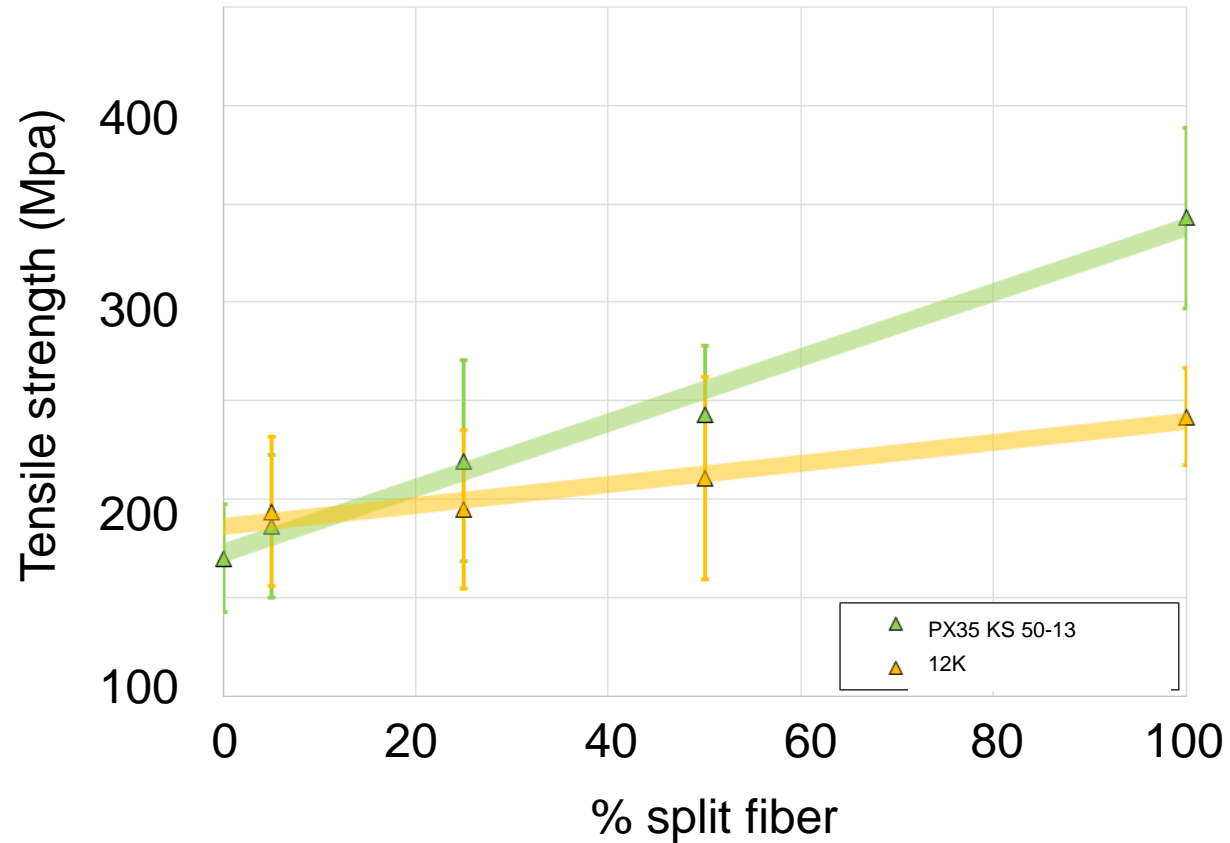
- Based on Zoltek PX35 50k tow
- Falls apart into 3k strands after chopping
- Can be processed in standard SMC sheet machines



Zoltek PX35 KS (split tow 3k)

# MECHANICAL RESULTS LAB-LINE AOC

Splitting up 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



# Mechanical Performance

Industrial Scale Results

## Daron 8151 CSMC 57% Wf

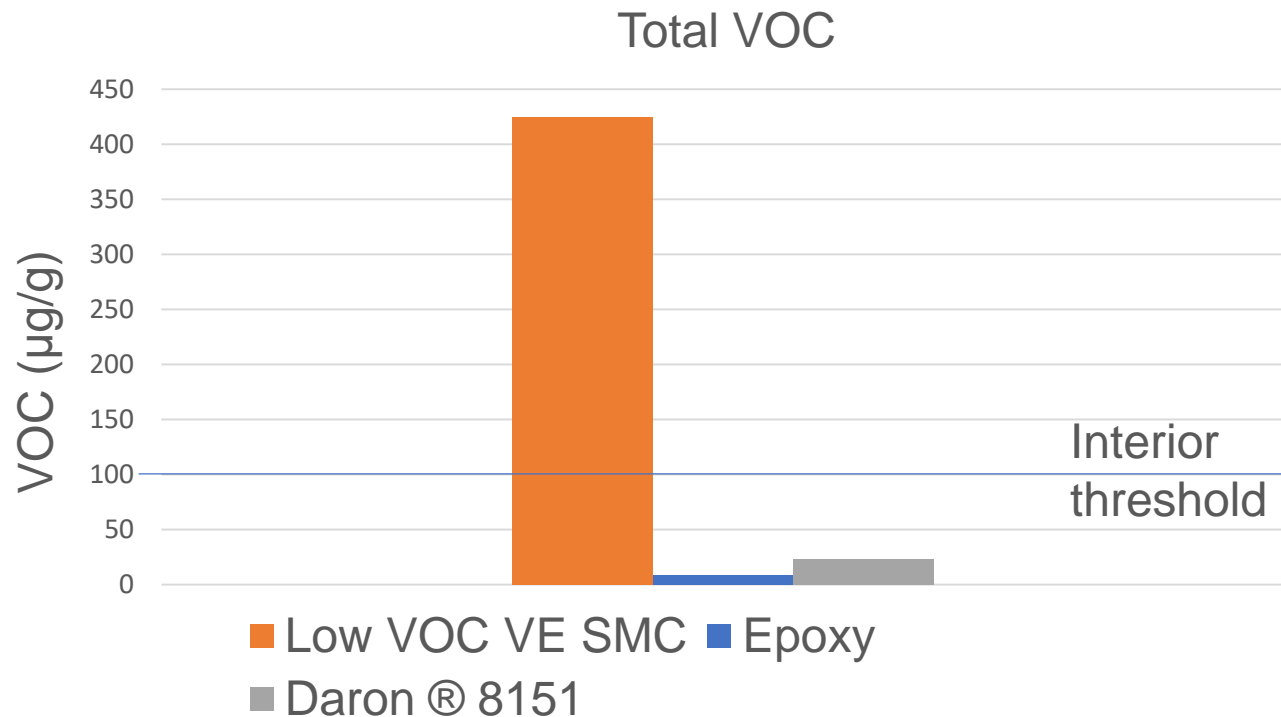
FIBRE	TENSILE MODULUS	TENSILE STRENGTH
50K splitted	36000	325

MATERIAL	FLEXURAL MODULUS	FLEXURAL STRENGTH
50K splitted	30500	460



# VOC EMISSIONS FROM MOLDED PARTS

Very low smell and emission, no styrene



	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

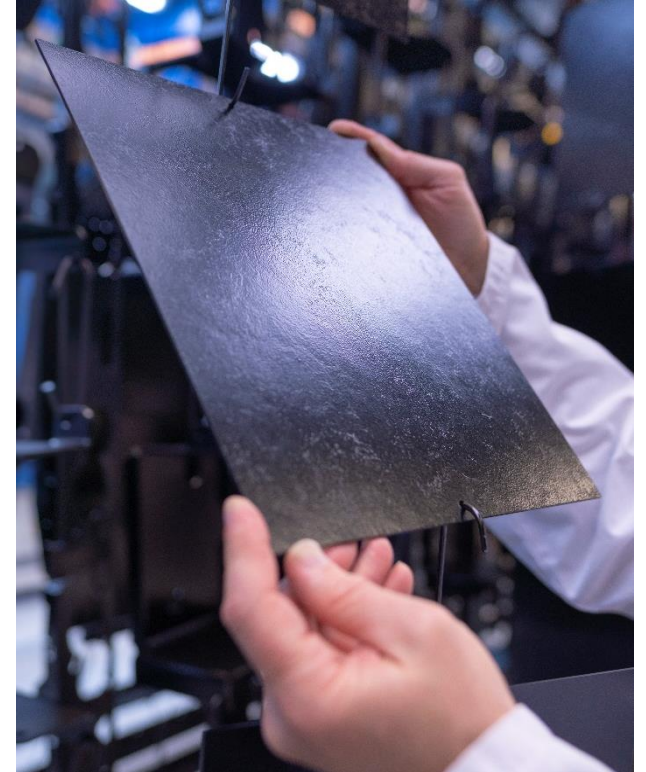
# DARON® 8151 E-COAT COMPATIBLE



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