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

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.groenevoud@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
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

**SMC PRODUCTION**
- 2 automated SMC lines
  - Max. Capacity: 27,000 TN/year

**BMC PRODUCTION**
- 2 automated BMC lines
  - Max. Capacity: 8,000 TN/year

**CSMC PRODUCTION**
- 1 NEW dedicated Carbon Fibre SMC line
  - Max. Capacity: 5,000 TN/year

**R&D CENTRE**
- 1 SMC / CSMC pilot machine
- 1 BMC / CBMC pilot machine
- 2 compression presses
- 1 injection machine
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
Supporting Our Customers Around the World

China
- Manufacturing, R&D
- Nanjing
- Sales Office
- Shanghai

Europe
- Manufacturing
  - Compiegne (F)
  - Filago (I)
  - Schoonebeek (NL)
  - Usti (CZ)
  - Pustkow (PL)
- R&D
  - Zwolle (NL)
  - Filago (I)
- EMEA/ Asia HQ
  - Schaffhausen (CH)

India
- Manufacturing
  - Wada
- Sales Office
  - Pune

US
- Manufacturing
  - Collierville, TN
- Americas HQ, R&D
  - Collierville, TN
- Collierville, TN; Valparaiso, IN; Perris, CA; Kathleen, FL

Canada
- Manufacturing
  - Guelph, ON

Mexico
- Manufacturing
  - Mexico City

China
- Regional HQ
  - Nanjing

China
- Manufacturing, R&D
  - Nanjing

Europe
- Manufacturing
  - Mexico City

Canada
- Manufacturing
  - Guelph, ON

US
- Manufacturing
  - Collierville, TN; Valparaiso, IN; Perris, CA; Kathleen, FL

India
- Manufacturing
  - Wada

India
- Sales Office
  - Shanghai

Europe
- EMEA/ Asia HQ
  - Schaffhausen (CH)
**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

<table>
<thead>
<tr>
<th>Property</th>
<th>SI</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>4,137 MPa</td>
<td>600 ksi</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>242 GPa</td>
<td>35 msi</td>
</tr>
<tr>
<td>Elongation</td>
<td>1.64%</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>1.81 g/cc</td>
<td>0.065 lb/in³</td>
</tr>
<tr>
<td>Fiber Diameter</td>
<td>7.2µm</td>
<td>0.283 mils</td>
</tr>
</tbody>
</table>
Zoltek’s Carbon Fiber Plants

One Zoltek PX35 50k carbon fiber quality from two separate, fully integrated locations: Hungary and Mexico.
Materials
Carbon provides biggest weight saving but cost is a challenge
CF-SMC offers the highest specific stiffness

![Graph showing specific tensile modulus vs. fiber volume content for various materials including Aluminum, Steel, Theoretical value CF-SMC, Practical feasible, and Theoretical value GF-SMC. The graph demonstrates that CF-SMC has the highest specific stiffness across different fiber volume contents.]
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.

Decreasing amount of added Isocyanate
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:

<table>
<thead>
<tr>
<th>Thermoplastics</th>
<th>Thermosets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Polyamide</td>
<td>Vinyl ester</td>
</tr>
<tr>
<td>High Temperature Thermoplastics</td>
<td>Polyester</td>
</tr>
<tr>
<td></td>
<td>Polyurethane</td>
</tr>
</tbody>
</table>
## Several Tow Formats

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Spreadable</th>
<th>Split</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape</strong></td>
<td>Conical (Rope-like)</td>
<td>Wide &amp; Flat</td>
<td>Split to 3k strands</td>
</tr>
<tr>
<td><strong>Product Code</strong></td>
<td>PX3505015T-13</td>
<td>PX3505015W-13</td>
<td>PX3505015K-13</td>
</tr>
<tr>
<td><strong>Spread</strong></td>
<td>Not spreadable</td>
<td>22-25 mm</td>
<td>&gt;20mm with several strands</td>
</tr>
<tr>
<td><strong>Twists</strong></td>
<td>Twisted</td>
<td>No Twist</td>
<td>No Twist</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>High AW fabrics</td>
<td>Low AW fabrics (150-300 gsm)</td>
<td>SMC</td>
</tr>
</tbody>
</table>

- Standard tow shape, rope style
- Spreadable tow shape, wide and flat
- Split tow with 3k substrands
ZOLTEK™ Split Fiber PX35 K for Sheet Molding Compound

Zoltek PX35 50k

Chopping

3k chopped fibers

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

Chopping & separating

50k 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

**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

*Standard SMC line at room temperature*
Picker/Dispersion Roll

There are two main types of Dispersion Rolls

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

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

**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
<table>
<thead>
<tr>
<th>Standard PX35 50k tow</th>
<th>PX35 KS tow</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Large tow with 50k filaments</td>
<td>• Based on Zoltek PX35 50k tow</td>
</tr>
<tr>
<td>• Suitable for SMC</td>
<td>• Falls apart into 3k strands after chopping</td>
</tr>
<tr>
<td>• Available with several sizings for Polyester resin, Epoxy resin, Vinylester resin</td>
<td>• Can be processed in standard SMC sheet machines</td>
</tr>
</tbody>
</table>

Zoltek PX35 50k

Zoltek PX35 KS (split tow 3k)
Splitting up Fiber Tow Increases Tensile Strength Considerably

![Graph showing the relationship between tensile strength (Mpa) and % split fiber. The graph indicates a positive correlation between the two variables.](image-url)
### 12K vs 50K Splitted Mechanical Performance
Industrial Scale Results

<table>
<thead>
<tr>
<th>VE CSMC 50% Wf</th>
<th>FIBRE</th>
<th>TENSILE MODULUS</th>
<th>TENSILE STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12K</td>
<td>27000</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>50K splitted</td>
<td>30000</td>
<td>240</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIBRE</th>
<th>FLEXURAL MODULUS</th>
<th>FLEXURAL STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>12K</td>
<td>25000</td>
<td>250</td>
</tr>
<tr>
<td>50K splitted</td>
<td>27000</td>
<td>330</td>
</tr>
</tbody>
</table>
### Superior Mechanical Properties

#### Industrial Scale Results

<table>
<thead>
<tr>
<th></th>
<th>FIBRE</th>
<th>TENSILE MODULUS</th>
<th>TENSILE STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>50K splitted</td>
<td>36000</td>
<td>325</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>MATERIAL</th>
<th>FLEXURAL MODULUS</th>
<th>FLEXURAL STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>50K splitted</td>
<td>30500</td>
<td>460</td>
<td></td>
</tr>
</tbody>
</table>
Very Low Smell and Emission (No Styrene) from Molded Parts

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

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