Pultrusion Conference 2021

Experimental Approach to Nanoparticles in the Pultrusion Industry

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Background information to Project

https://project-oasis.eu/

Open access single entry point for scale-up of innovative Smart lightweight composite materials and components
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814581

Open **A**ccess **S**ingle entry point for scale-up of **I**nnovative **S**mart lightweight composite materials and components

Project description:

The OASIS project aims at fulfilling market potential of nano-enabled multifunctional lightweight products by:

- Gathering the manufacturing capacity of **12 pilot lines** from nanoparticle-production to final product.
- Establishing a **thorough service offer** for associated technical & business development
- Granting direct access to the whole ecosystem through a **Single Entry Point (SEP)** for easier access especially for SMEs.

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Consortium:

- Technical service providers:
  - Tecnalia, CEA, IPC, Fraunhofer Gesellschaft, University of Patras, TMBK Partners, Alfred-Wegener-Institut, Universidad de Castilla-La Mancha, Sisteplant, Spanish Association of Standards, Adamant Composites
- Non-technical service providers:
  - Amires, Blumorpho, Tecnalia Ventures
- Industrial end-users
  - Airbus, Acciona, Ford, Thales, Pleione Energy, VDL Fibertech Industries

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Showcases

Nano-enabled pultrusion for lightweight construction	responsible partner: ACCIONA	acciona Construction
Structural Nanoreinforced Al castings	responsible partner: Ford-Werke	Ford
Multifunctional RTM composite panels for roofs and sidewalls of e-buses	responsible partner: VDL Fibertech Industries	VDL Fibertech Industries
Smart battery casing in nanocomposite for aeronautic applications	responsible partner: Thales	THALES
Multifunctional nanobased layer for aeronautical structure	responsible partner: AIRBUS Operations	AIRBUS
Energy Storage in prefabricated walls	responsible partner: Pleione Energy	PLEIONE ENERGY

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Nano-enabled pultrusion for lightweight construction



The problem	The solution	The services used
Current gaps in the technology: • Mechanical performance at elevated temperatures • Slow productivity • Durability to aggressive conditions **Requirements and specifications:** 1. Rebar with enhanced mechanical performance at elevated temperatures/fire 2. Higher productivity of the rebar pultrusion 3. Corrosion resistant nano-enabled coating for RC elements **Technical requirements:** • Meet or enhance the specifications of the state of the art rebars	**1. Rebar with enhanced mechanical performance at elevated temperatures** • Enhanced mechanical performance **nano-particles** specified to this need are used. A multifunctional tool particle is created using layered double hydroxides as flame retardant component. **2. Higher productivity of the rebar pultrusion:** • Enhanced productivity and lower costs **nano-particles** specified to this need are used. A multifunctional tool particle is created using inductively heatable magnetic particles. **3. Corrosion resistant nano-enabled coating for RC elements**	**1. Rebar with enhanced mechanical performance at elevated temperatures** **2. Higher productivity of the rebar pultrusion:** • Production of magnetic particles and layered double hydroxides, as well as the combination to multifunctional tool particle. • Process evaluation and modification of the pultrusion process with nanomodified resins • Thermal, mechanical testing of reinforced concrete beams • Design of fire resistence solutions for FRC reinforced concrete beams **3. Corrosion resistant nano-enabled coating for RC elements** • Production of nanomodified coating • Testing of the corrosion resistance

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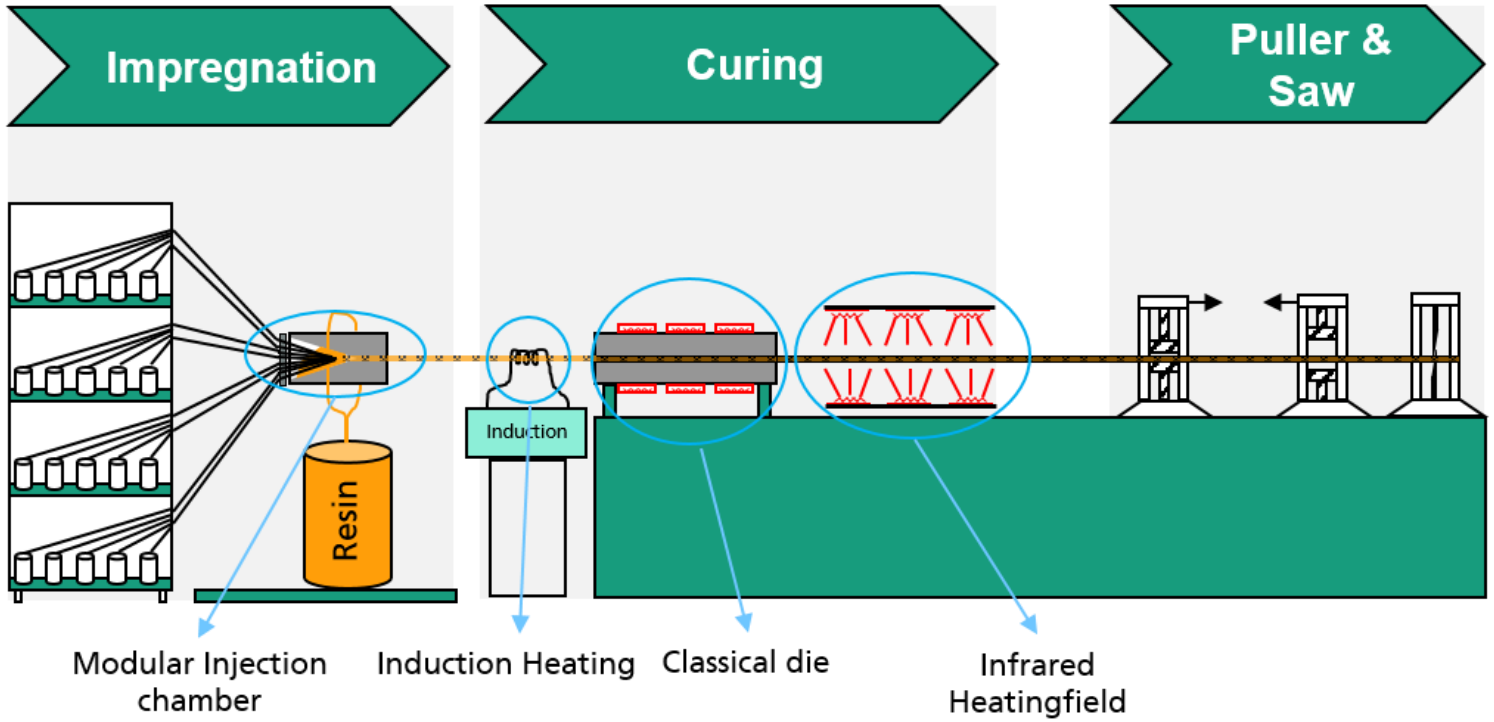
Experimental Approach to Nanoparticles in the Pultrusion Industry

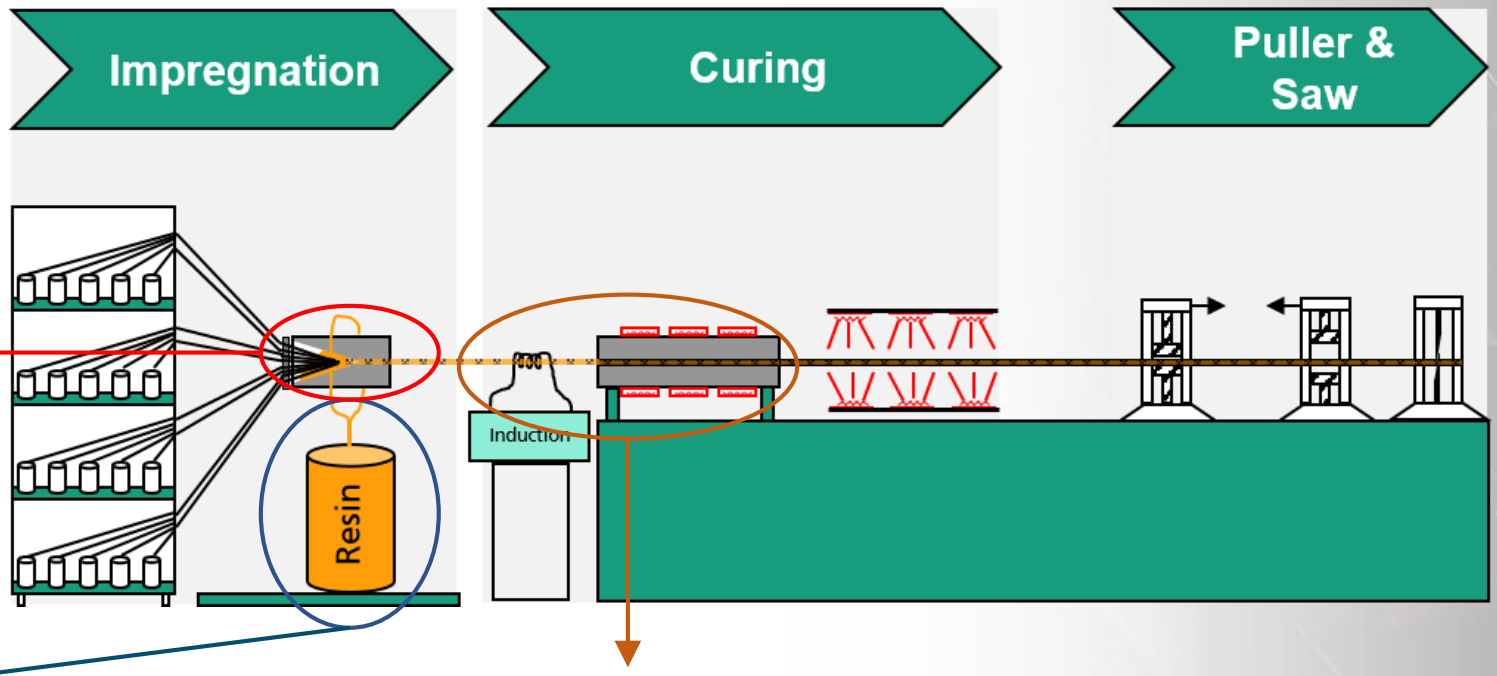


Particles and parameters:

- Particles:
  - LDH
  - MAGSILICA®
- Resin:
  - Vinylesther
- Fibers:
  - OCV PS4100 4800tex
- Cross-section:
  - 16 mm diameter
  - No surface modification
  - Curing die and injection chamber

Experimental Approach to Nanoparticles in the Pultrusion Industry

Investigated factors:



Influence on the impregnation:
- Fiber distribution
- Particle distribution

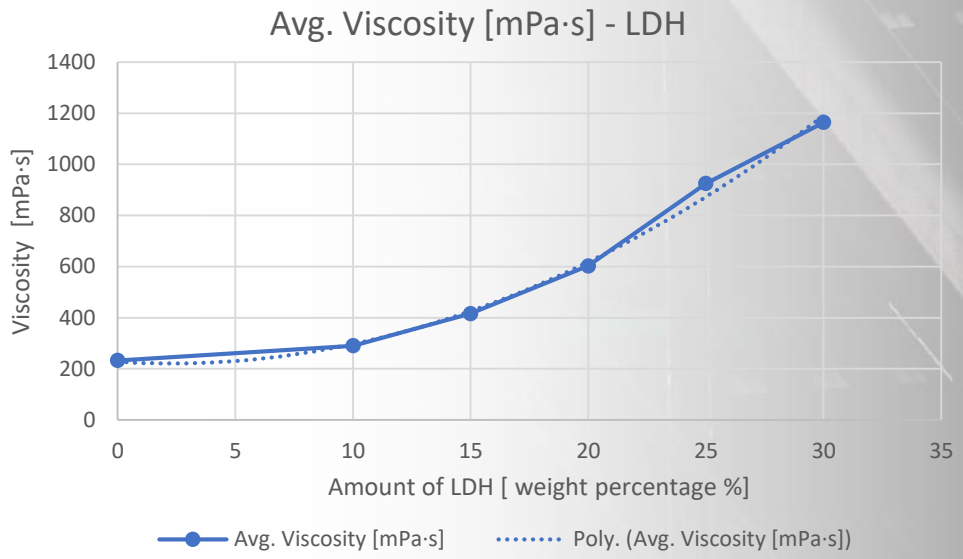
Influence on the resin:
- Viscosity
- Curing

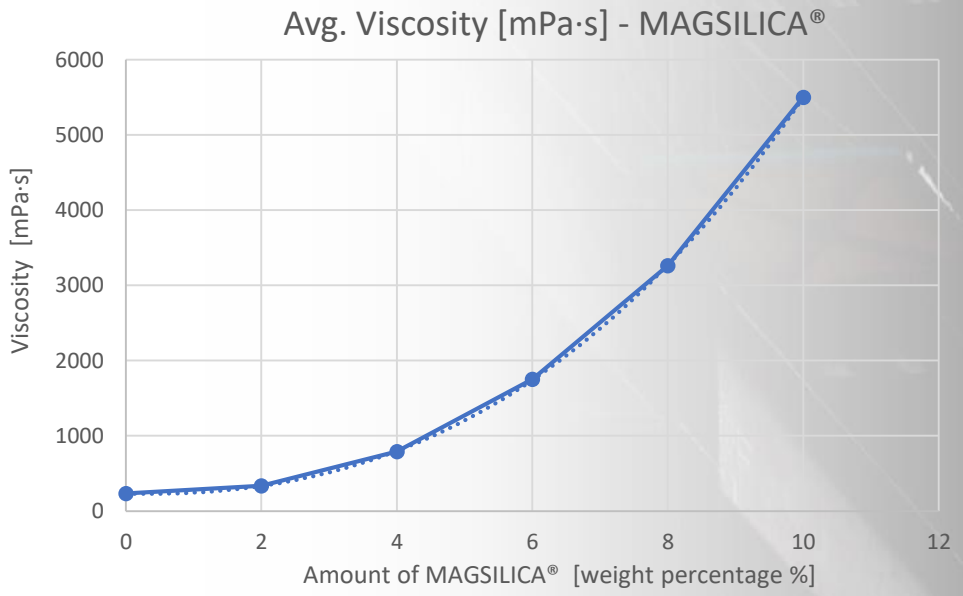
Influence on the pultrusion process:
- Speed
- Quality

Influence on the resin

Viscosity:

- LDH particles
  - Moderate increase
  - Shear force not high enough to lower the particle size
- MAGSILICA® particles
  - Significant increase
  - Small particle size and non-modified for the resin



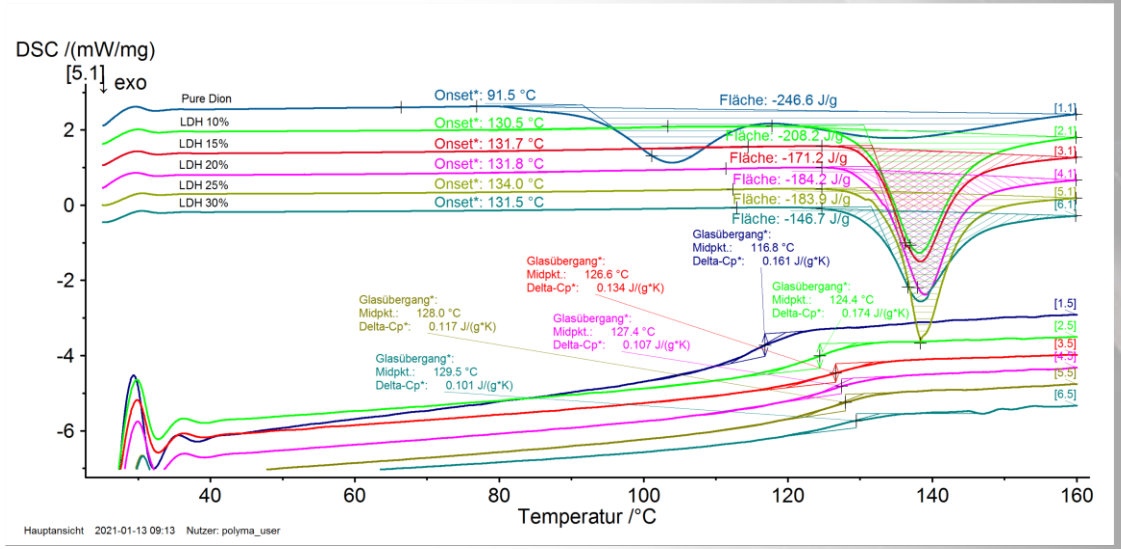


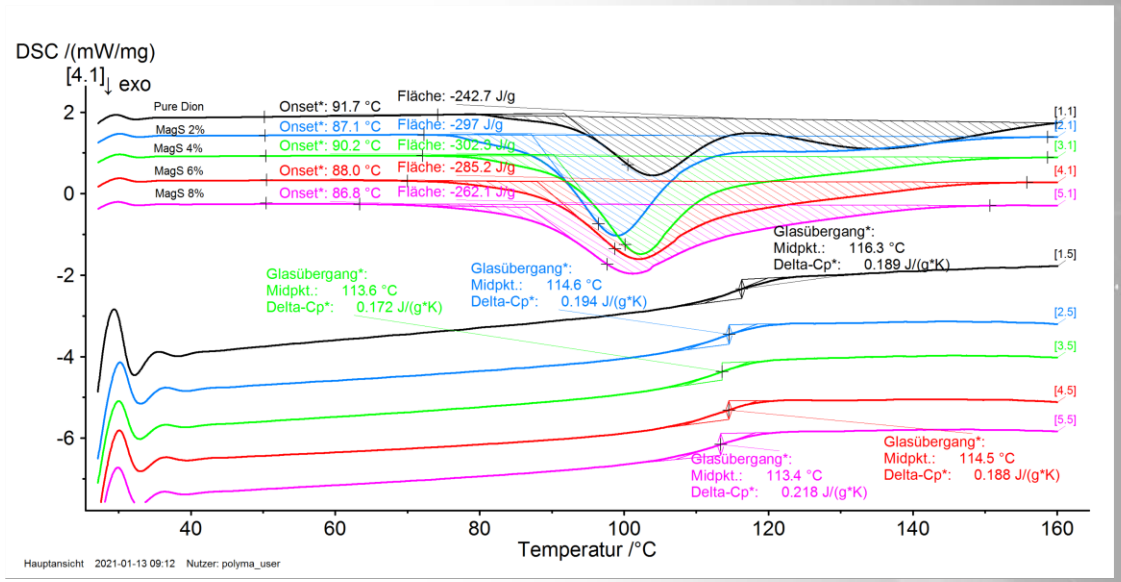
Influence on the resin

Curing:

- LDH particles
  - Interacts with the peroxides
  - Slows down the reactivity

- MAGSILICA® particles
  - Interacts with the peroxides
  - Inhibits the reactivity

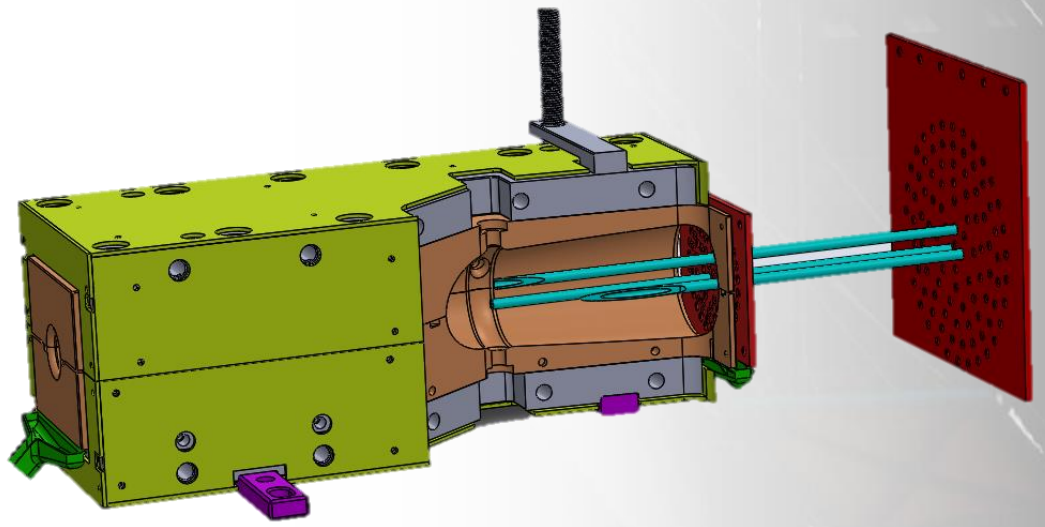




Influence on the impregnation

Modular Impregnation Chamber:

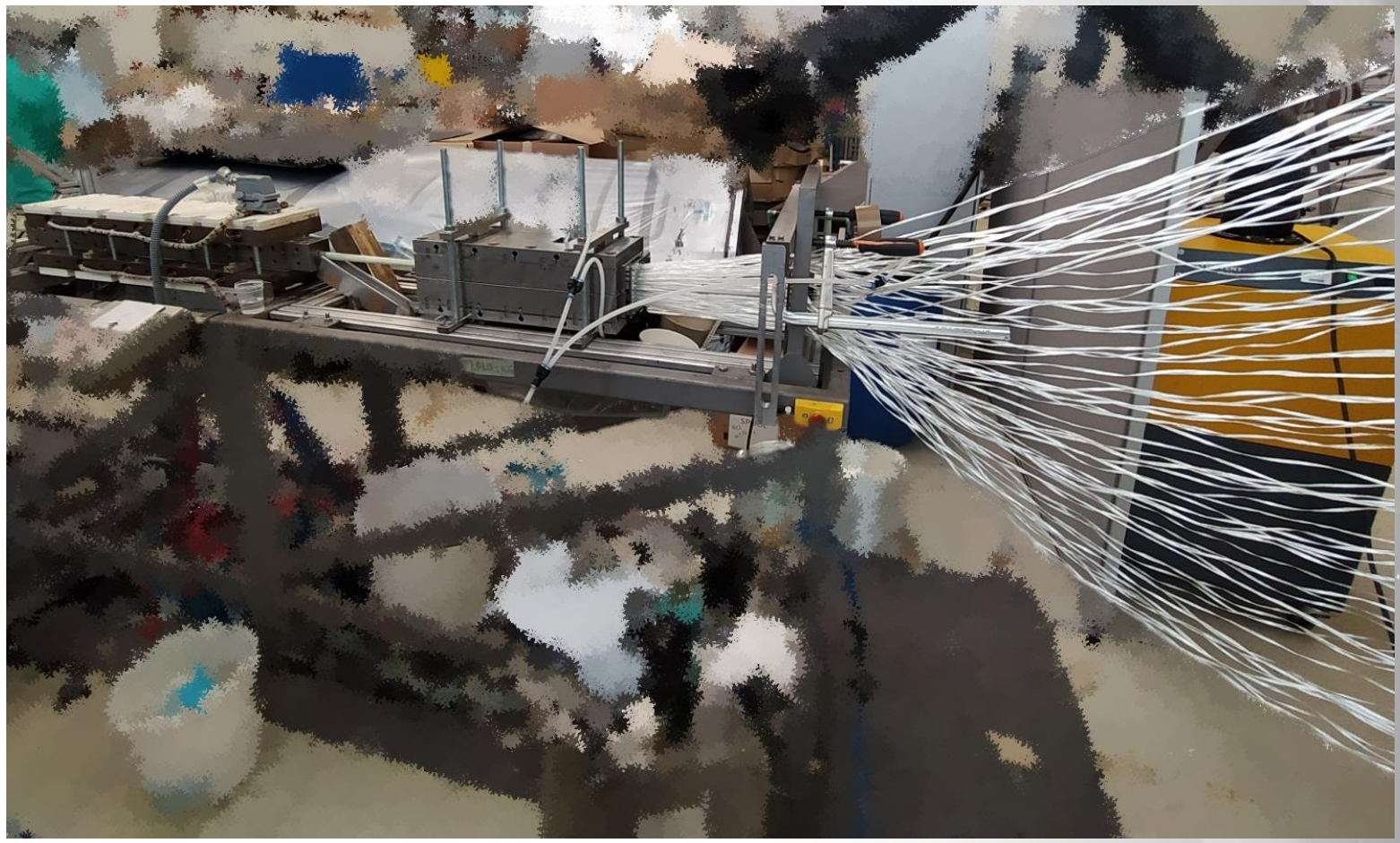
- 5 injection points
  - 3 center back injection
  - 2 outside injection (above and below)
- Homogeneous fiber distribution through fiber guiding plates
- Impregnation: Pressure pot



Influence on the impregnation

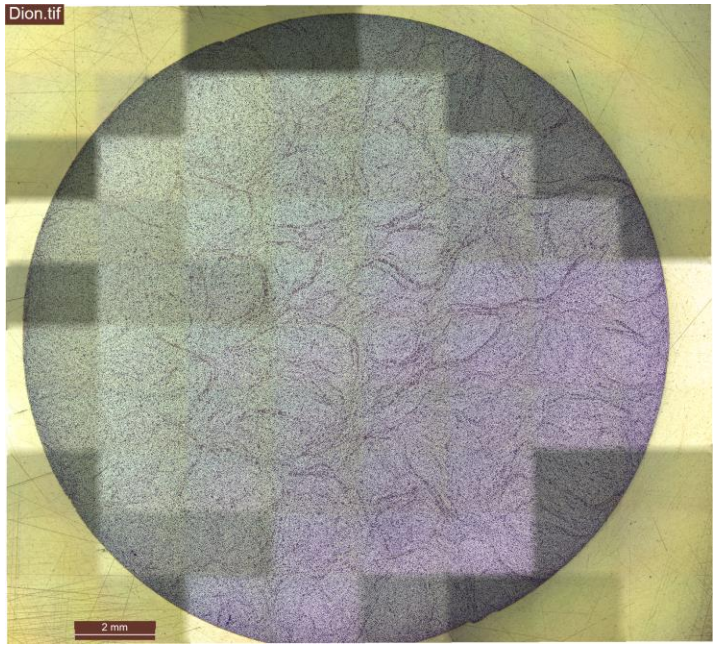
Trial setup:

- Material:
  - VE, VE+LDH, VE+MAGSILICA®
- Speed:
  - 0,2 m/min
- Temperature:
  - 75/110/140 [°C]

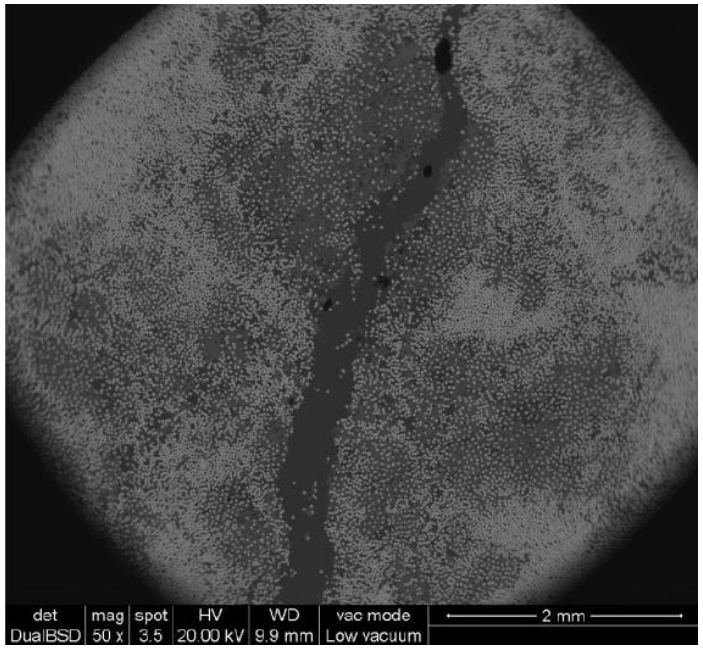


Influence on the impregnation

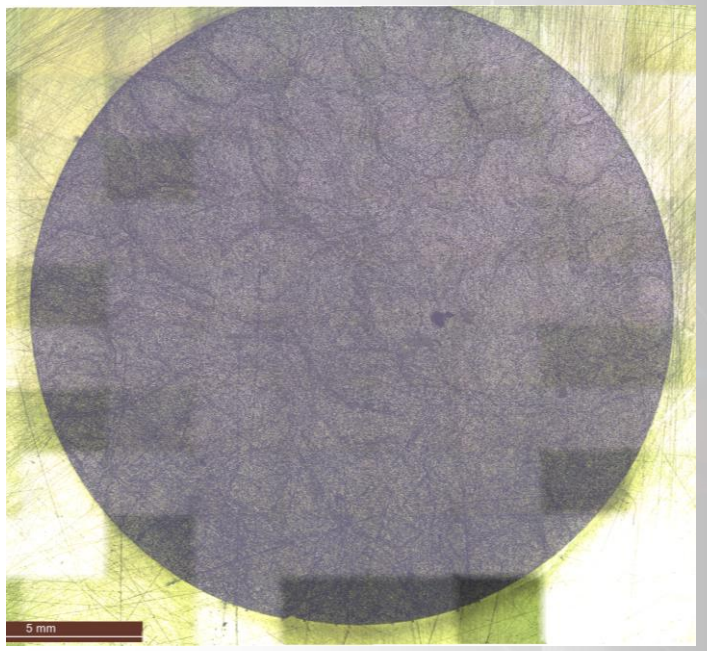
No particles:



LDH:

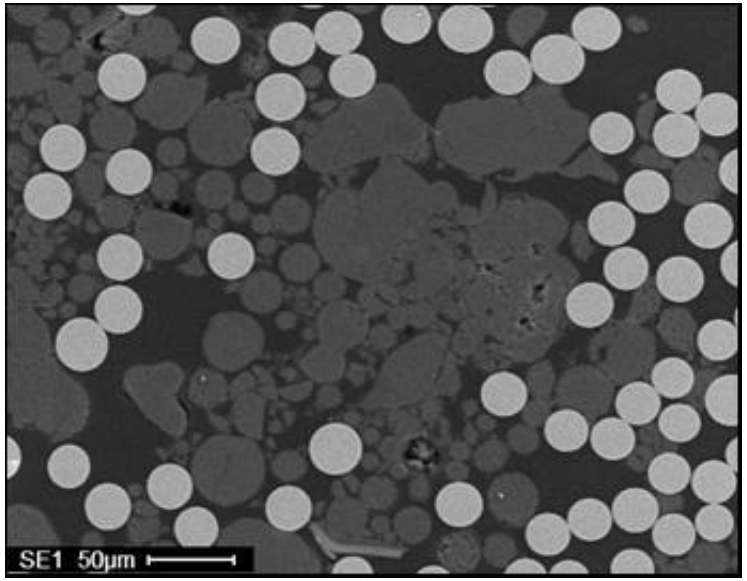


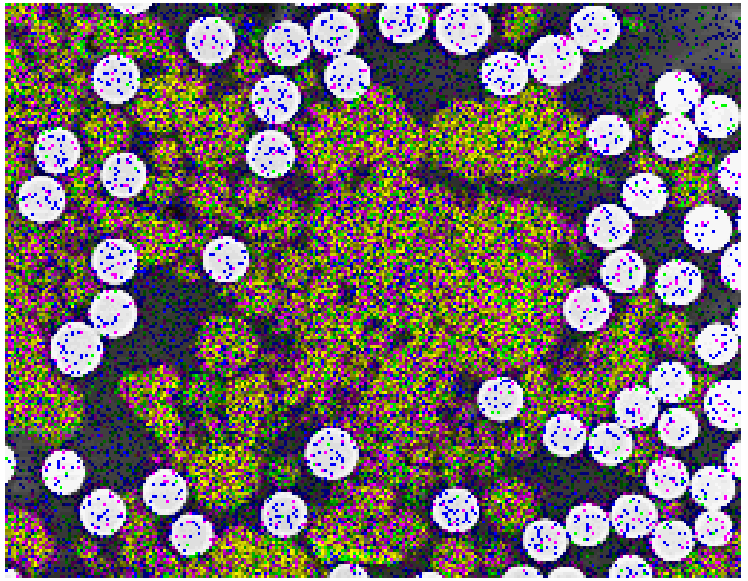
MAGSILICA® :

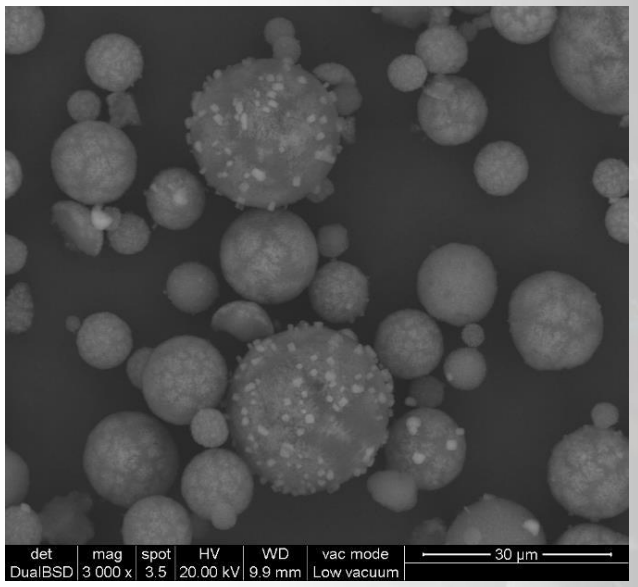


Influence on the impregnation

Investigation of the LDH samples with SEM and EDX



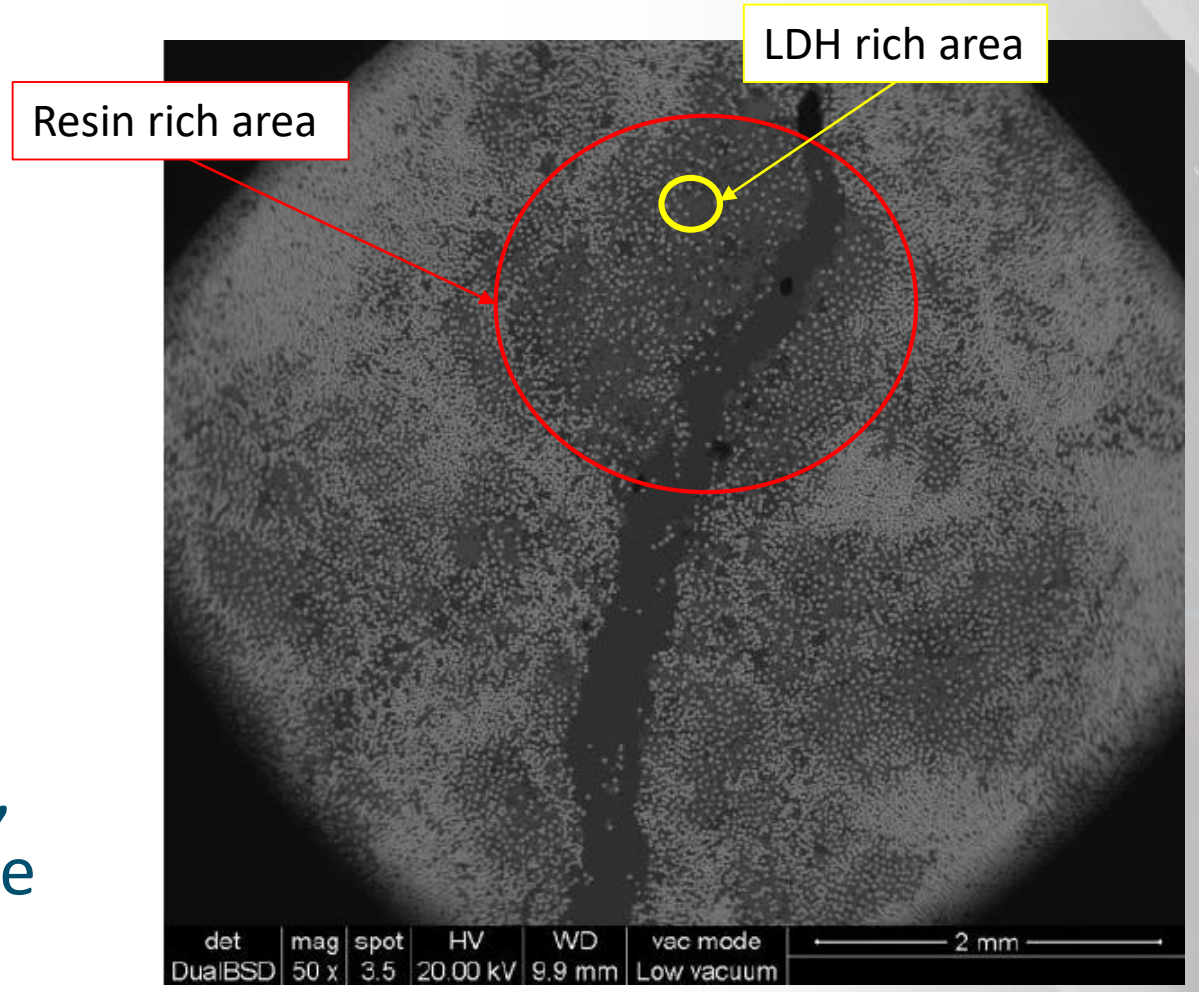




Influence on the impregnation

LDH:

- Resin rich in the center
- Distribution of the LDH also focused on the center



Filtration effect of the LDH caused by the injection position, fiber guiding and the particle size

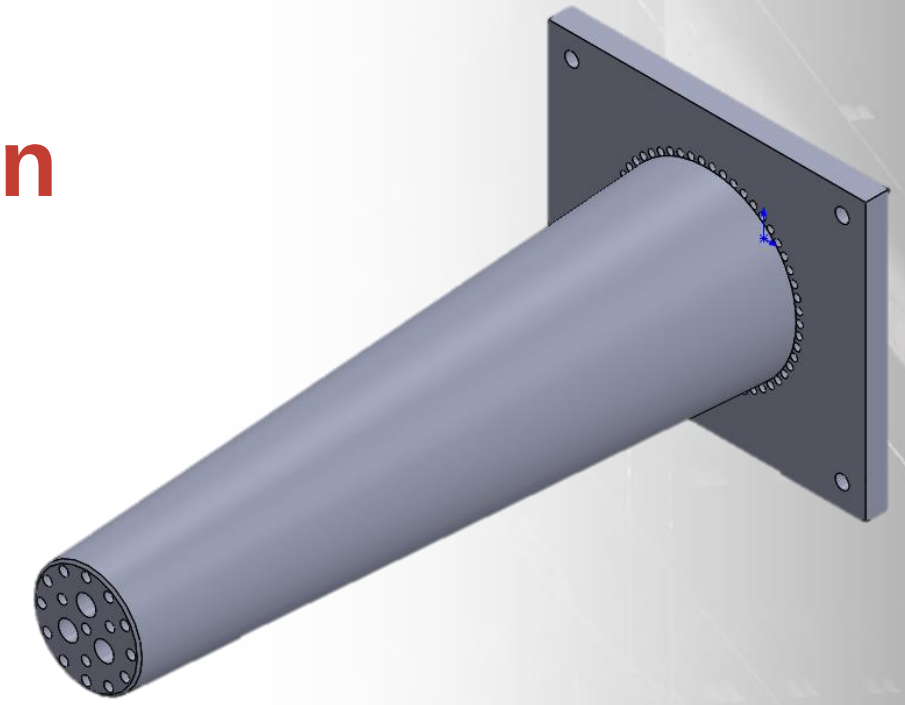
Influence on the impregnation

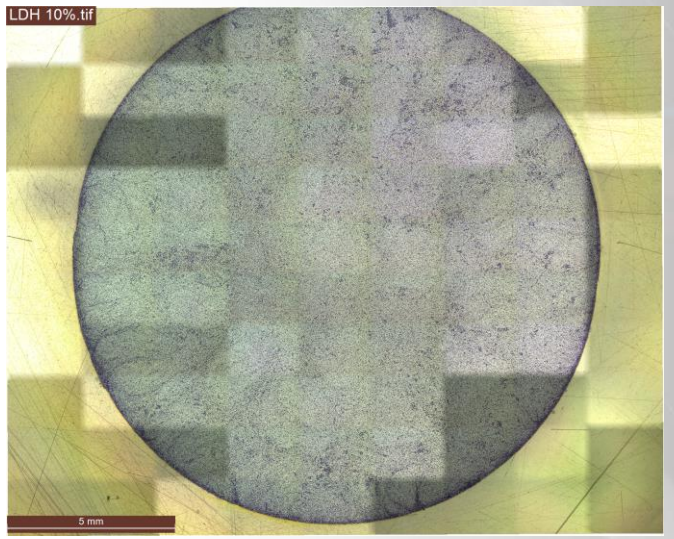
New design for the back injection

- Improving the material loss of the injection chamber
- Fibers are guided in the chamber

Results:

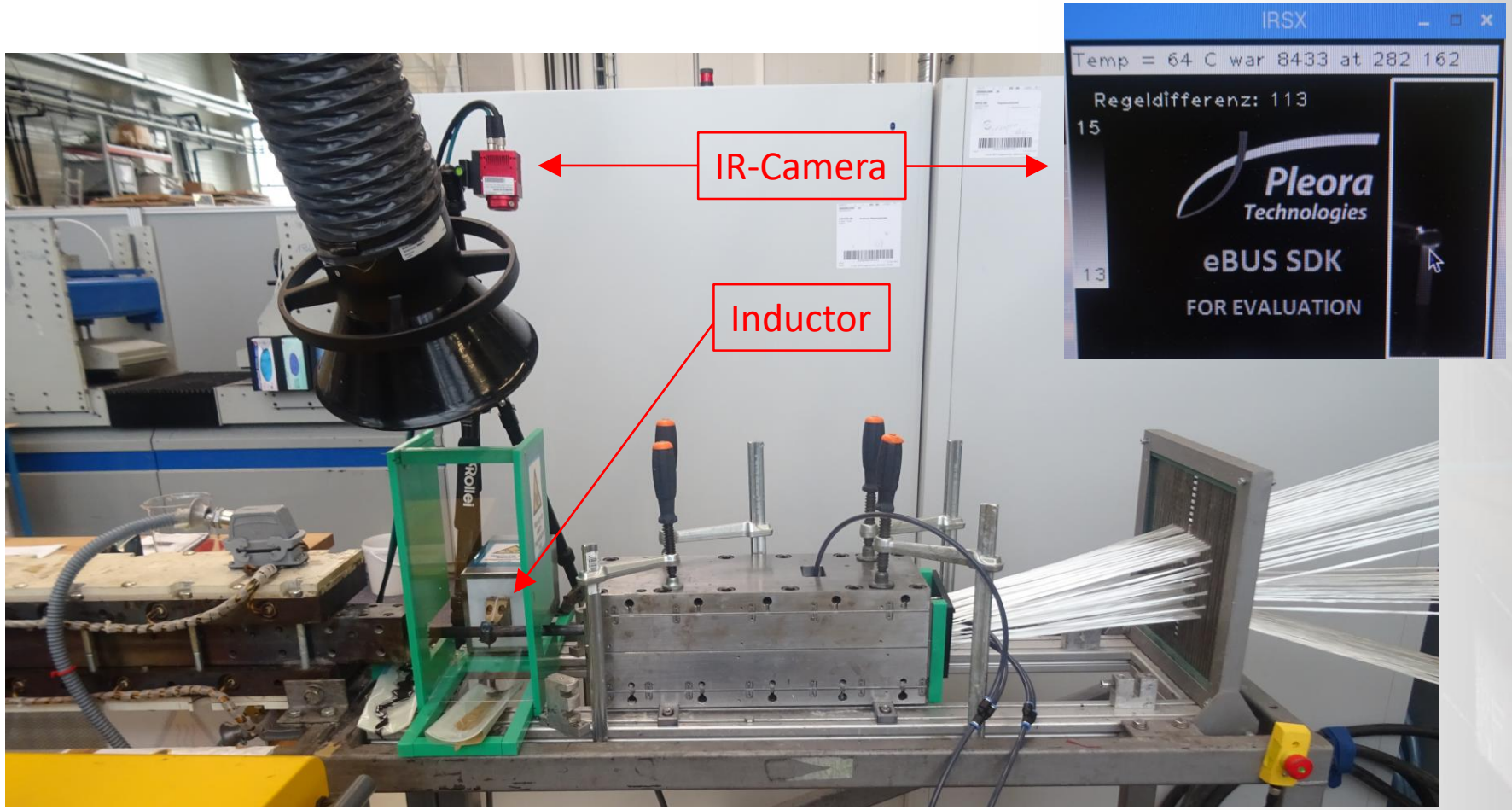
- Resin consumption was reduced
- Homogeneous fiber distribution
- Crack in the profile was resolved
- SEM is pending





Influence on the pultrusion process

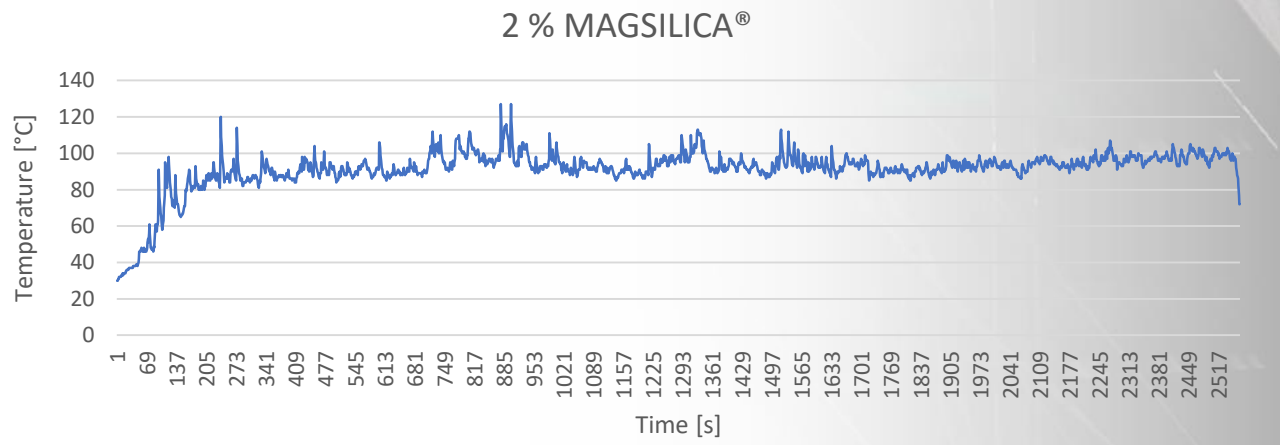
Setup:

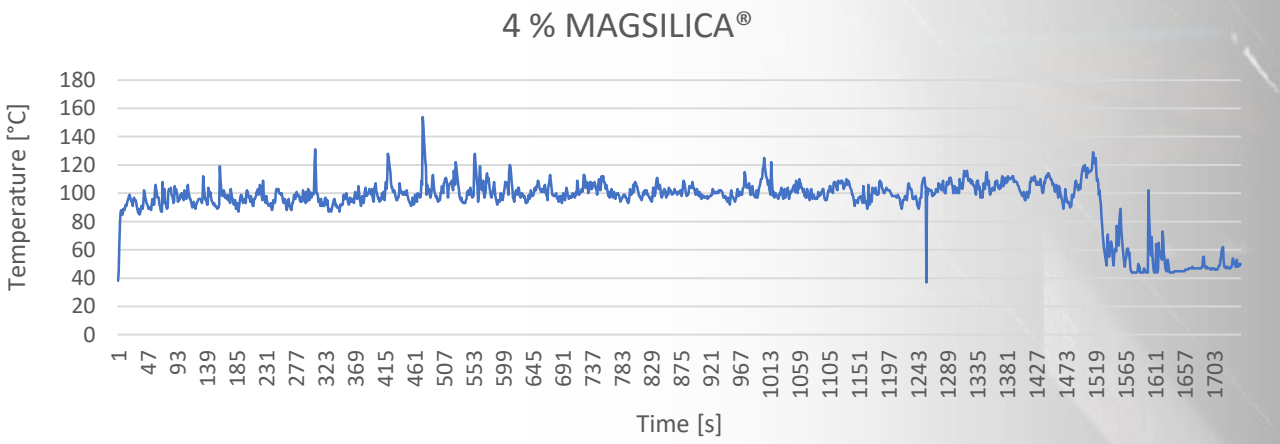


Influence on the pultrusion process

Temperature increase:

- 2 % MAGSILICA®
  - Stable temperature profile
  - Speed 0,33 m/min
- 4 % MAGSILICA®
  - Stable temperature profile
  - Speed 0,45 m/min

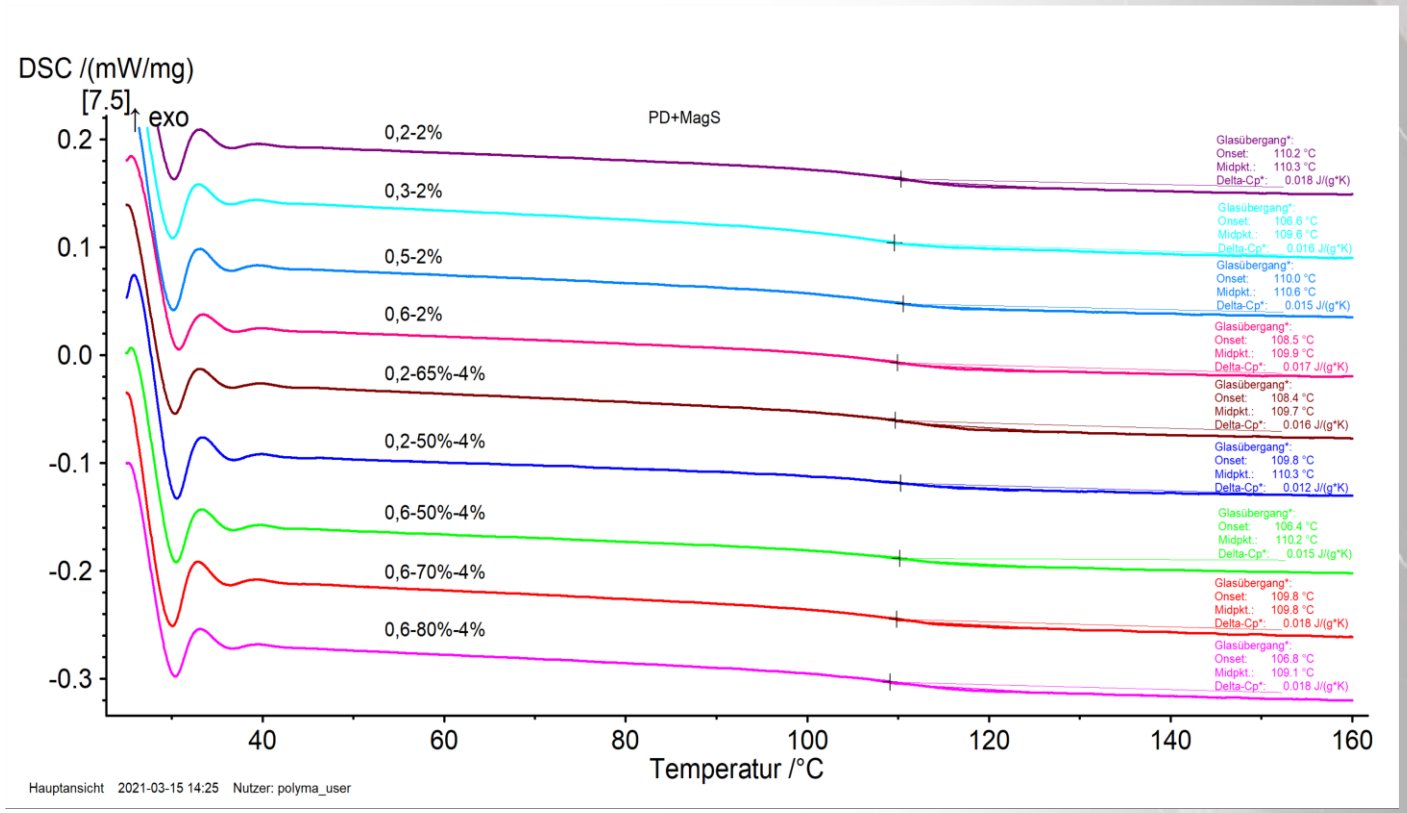




Influence on the pultrusion process

DSC measurements:

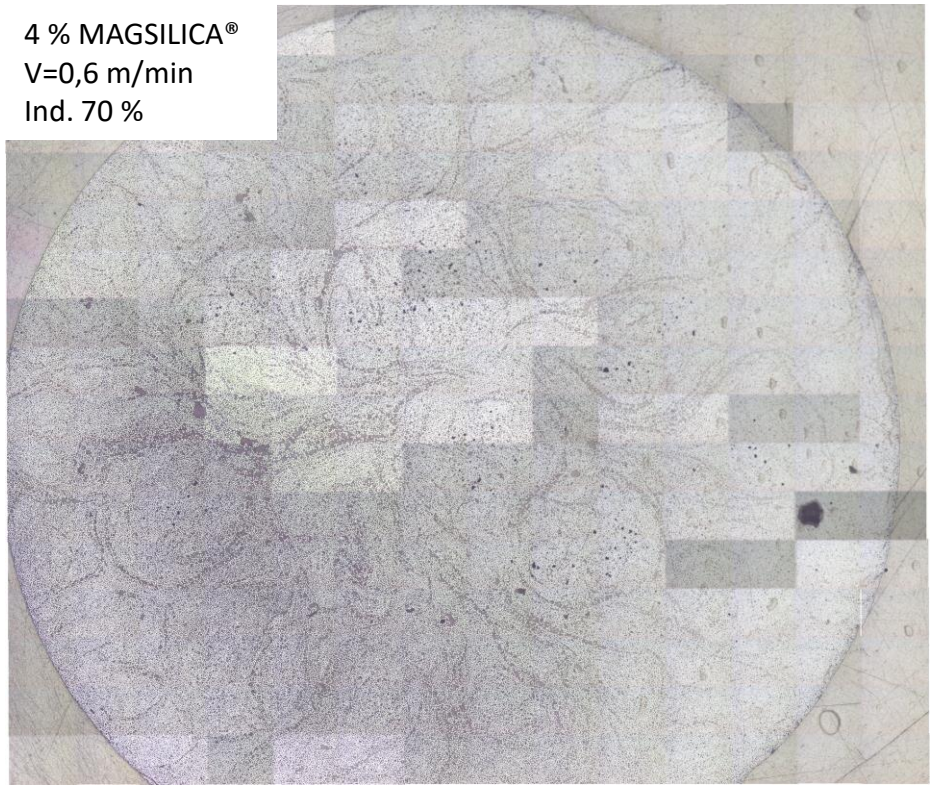
Crosslinking degree and
TG are not effected



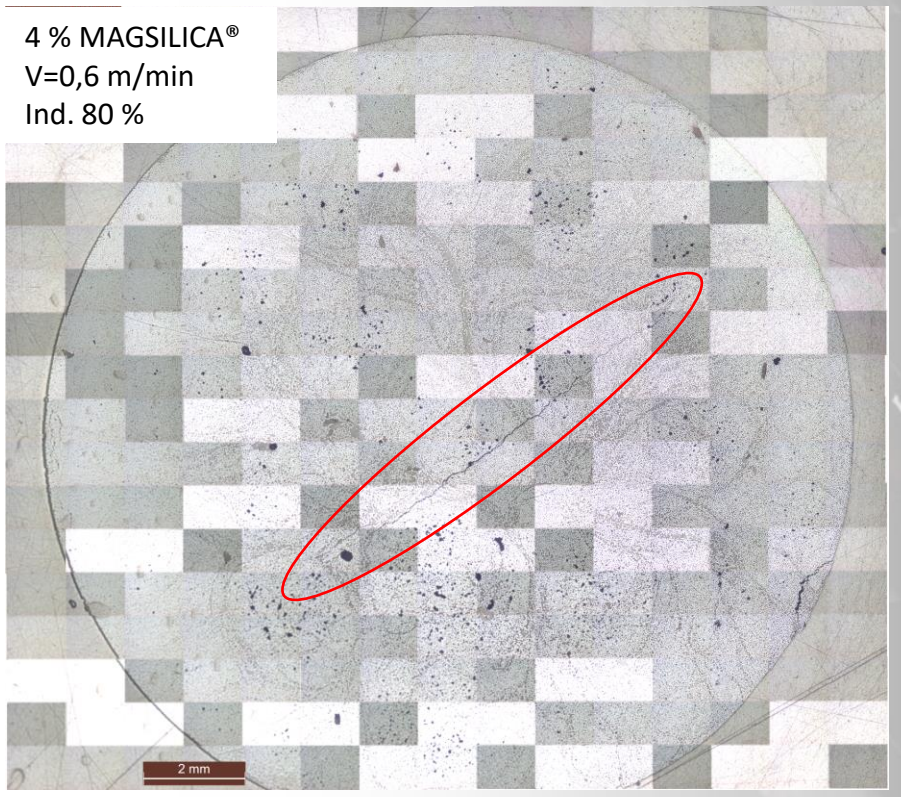
Influence on the pultrusion process

Influence of the induction system

4 % MAGSILICA®
V=0,6 m/min
Ind. 70 %



4 % MAGSILICA®
V=0,6 m/min
Ind. 80 %



Conclusion

- Chemical influence on the resin has to be considered
- Particle size and viscosity have to be considered
- Inductive heating is a suited method to increase the pultrusion speed

- Further steps:
  - Limitations of the line speed in combination with IR-Heater curing
  - Evaluation of the LDH enhanced rebars (mechanical and thermal)
  - Process optimization for LDH enhanced rebars

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Thank you for your attention!

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