CUSTOMISIZE

Customisize | Workshop

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Advanced Polymers Area

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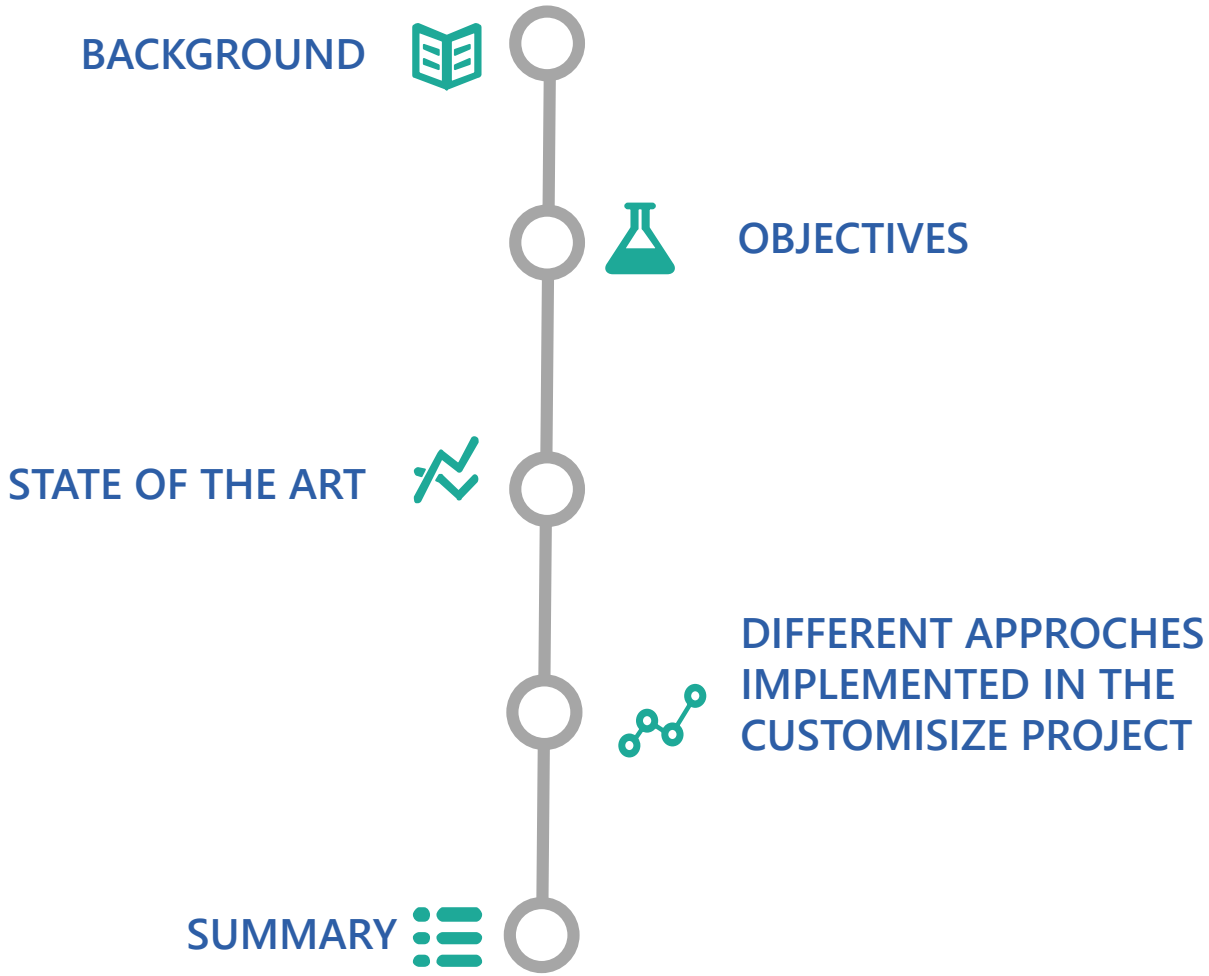
Outline



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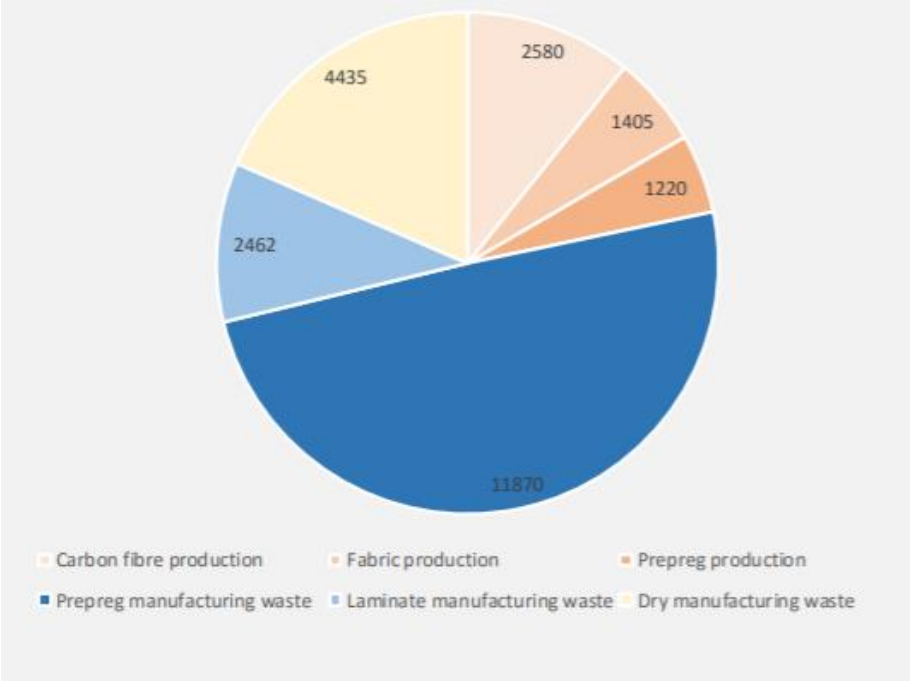
Background

=The recent environmental regulation, social concerns and growing environmental understanding throughout the world have led to renewed efforts in the recycling industry.



Almost 24.000 tonnes of CF available from waste in 2016

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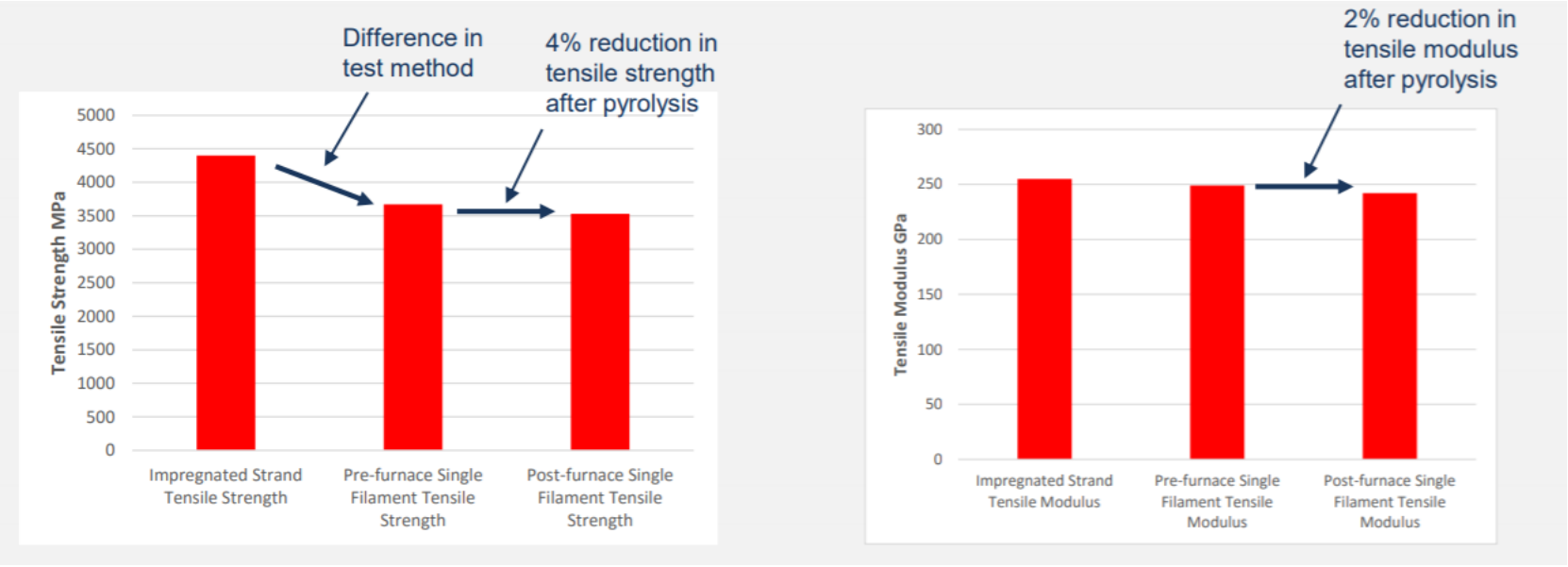
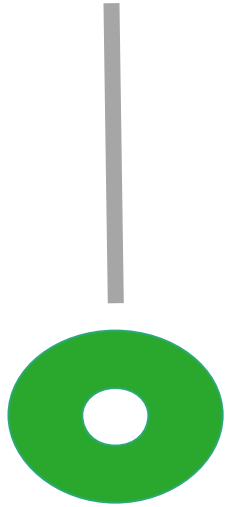
Background

=Nowadays, it is viable to recycle carbon fibre without damaging the fibre. As outcome, aside the absence of sizing and the length, rCF there is no notable difference between a virgin carbon fibre and recycled carbon fibre.





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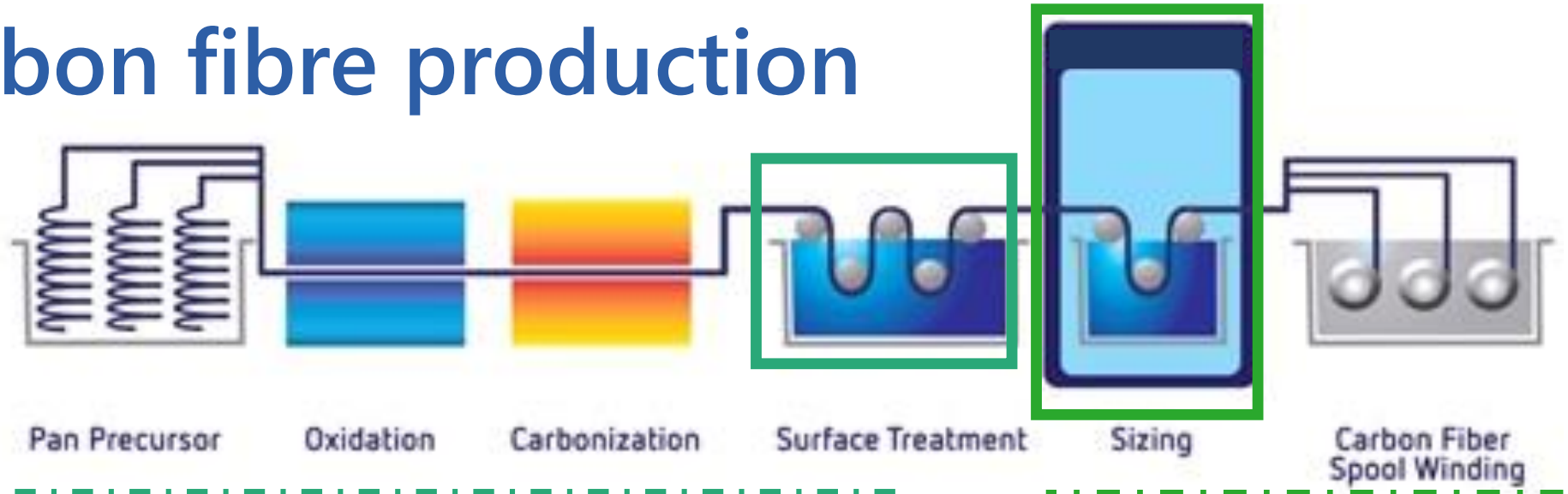
Carbon fibre production



Electrolitic processes are used in the industry

= These process enhances the surface energy and surface reactivity of the carbon fibres forming oxygen containing functional groups.

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= Development of new sizing for rCF:

- PPS, PEKK
- PU, EPOXY
- Cementitious materials

The two treating process should be carried out together for obtaining better interfacial bonding and mechanical properties of composites

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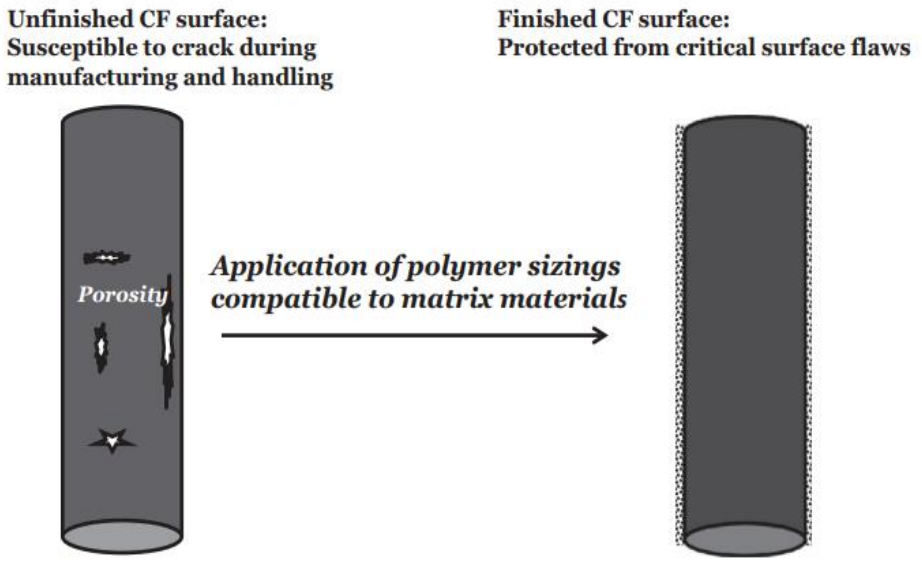
Review of state of the art sizing materials

Sizing is a method to protect filaments (both in roving and fabrics form), which undergoes various contacts during manufacturing

Also, provide a chemical link between the fibre surface and the matrix



Improve the fibre-matrix adhesion

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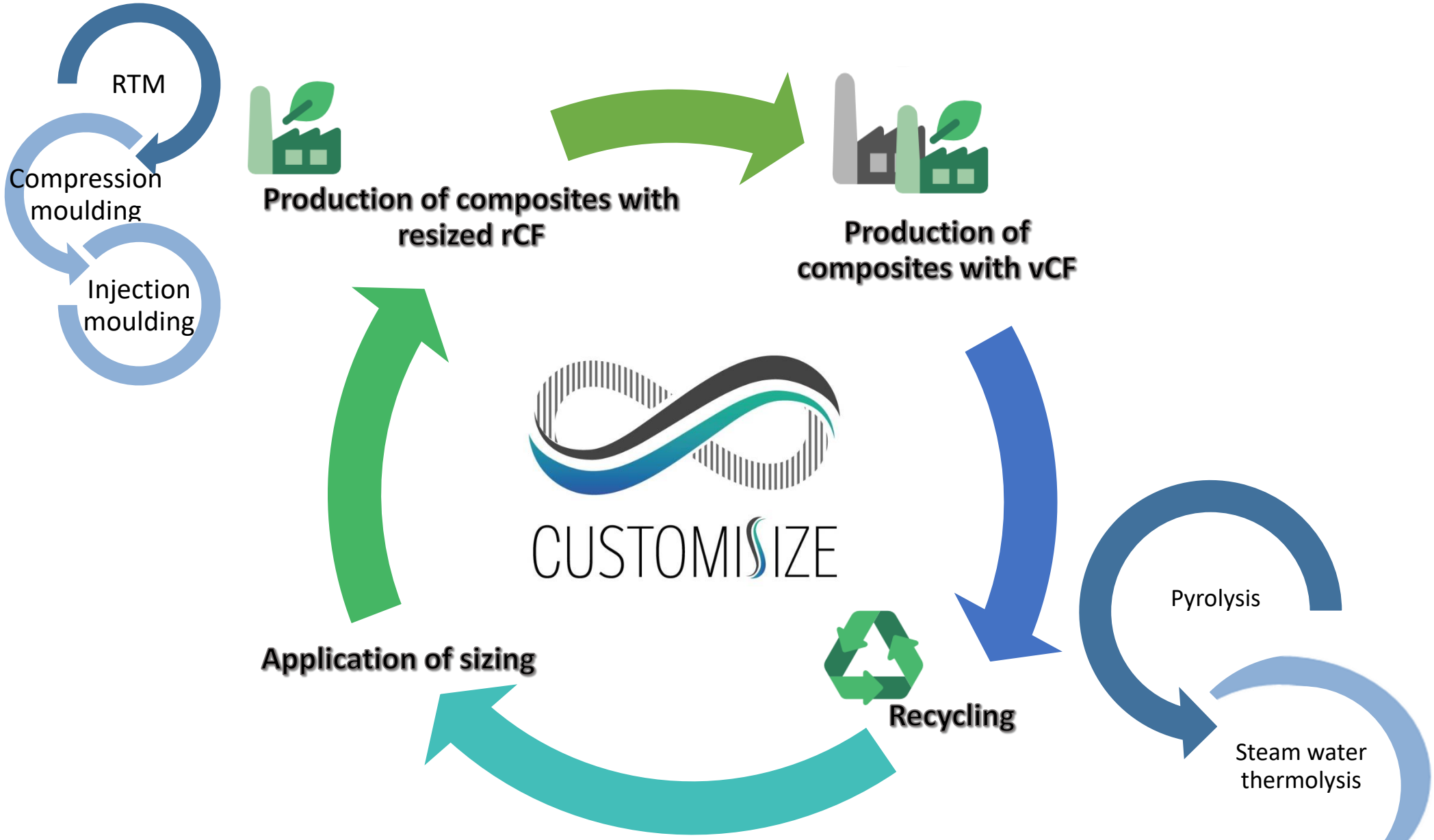

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Objectives

Development of a new family of CF sizing strategies to improve the interfacial adhesion between (rCF) and polymeric and cementitious matrices

- **The resized mats and chopped fibre tows will improve the strength and toughness of the reinforced composites and will reduce their environmental impact.**
- **New approaches, such as Steam Water Thermolysis (SWT), Polyhedral Oligomeric Silesquioxanes (POSS) and Plasma Treatments will be used to increase rCF-matrix interfacial adhesion.**

A new family of composites materials will be prepared with the resized rCF

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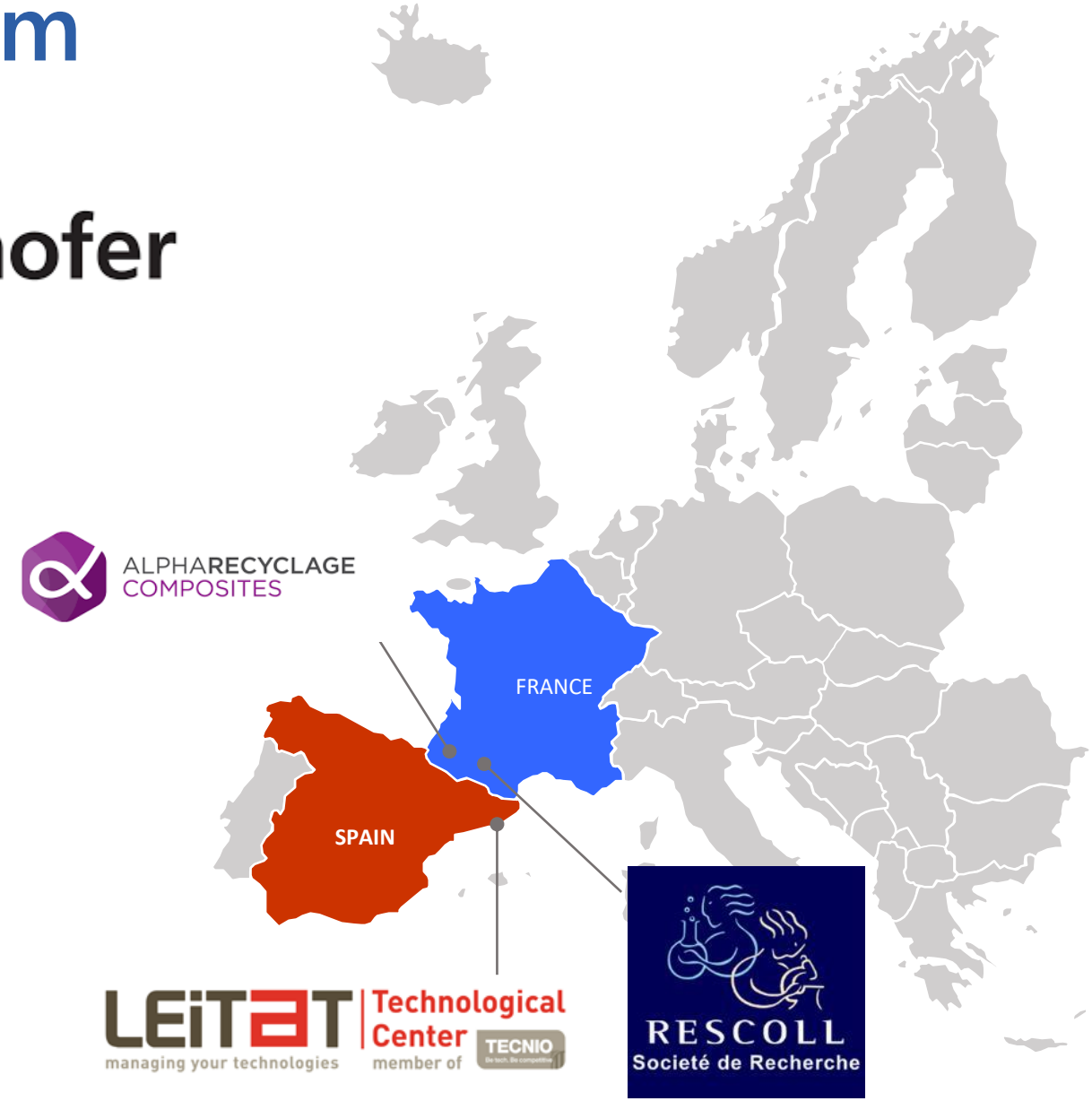
Consortium

Fraunhofer



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Review of state of the art sizing materials

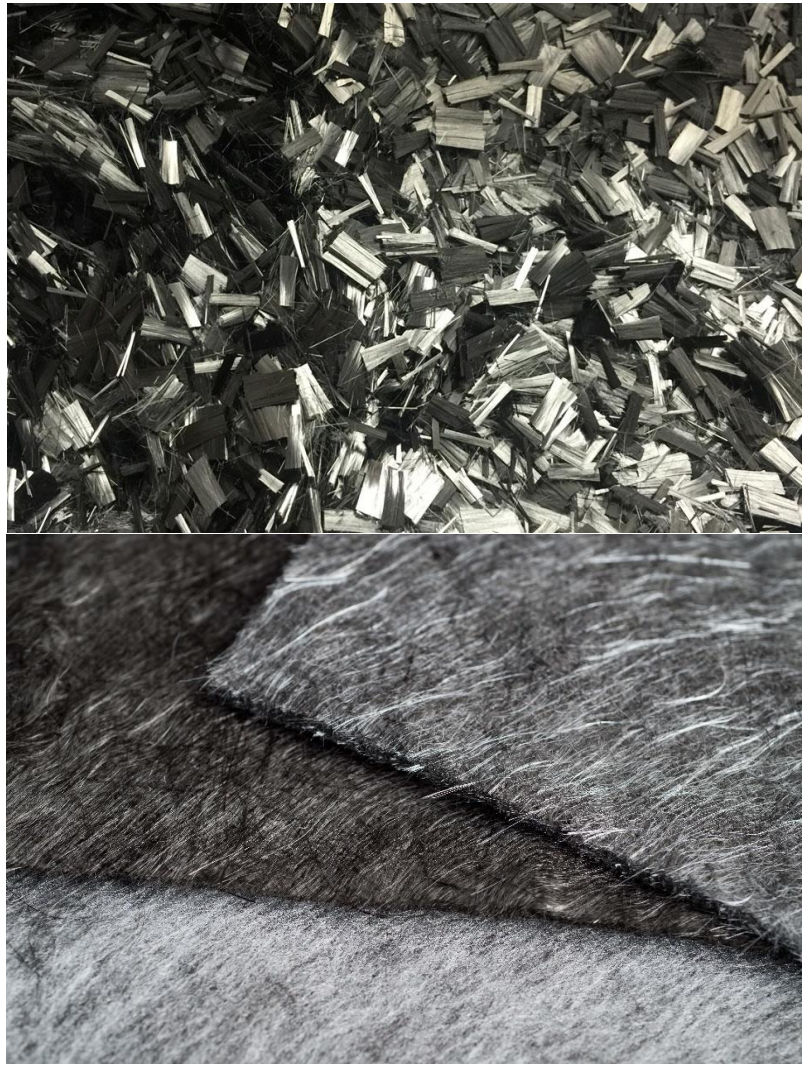
Carbon fibre sizing´s requirements:

- **Mw:** the sizing molecular weight (Mw) influences the fiber/matrix interfacial adhesion. Also, it depends on the fabrication process:

- In chopped fibre, it is important good bundle integrity=↑Mw

- In continuous fibre, it might use a sizing that enables greater filament spreading for easier wetout=↓Mw

- The sizing must form film



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Identification of interlinkage mechanisms between recycled carbon fibres and matrix materials

Good wetting of the fibre by the matrix

↓

Surface energy of the fibre is greater than that of the matrix

Chemical reactions at the interface

↓

Bond created between the chemical group on the CF and another chemical group in the matrix

Mechanical bonding

↓

Interlocking at the fibre surface

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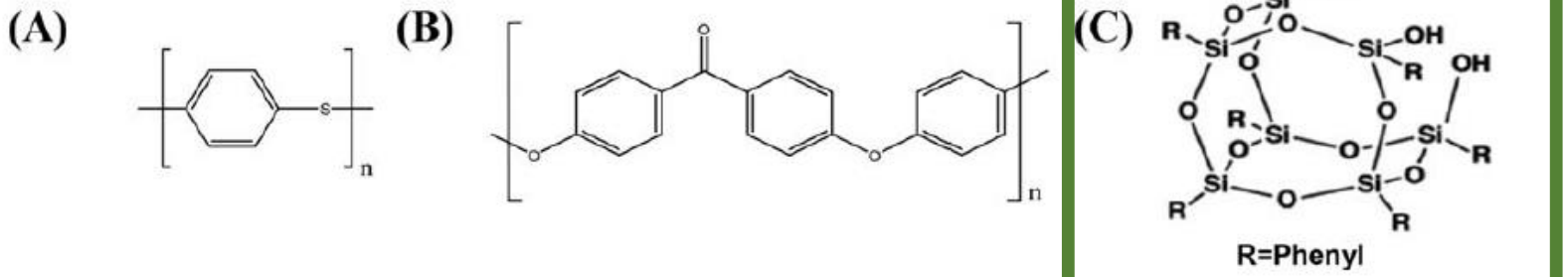
Review of state of the art sizing materials

Matrix: PPS and PEKK ⟶ POSS sizing

It is supposed that coat the fiber with a ductile layer could act as a stress relief medium and reduce the stress concentration



(A) PPS (B) PEKK (C) Tsp- POSS

POSS molecules are the smallest known particles of silica and have a cage-shaped three-dimensional structure

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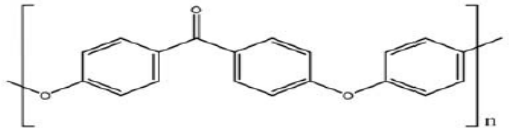
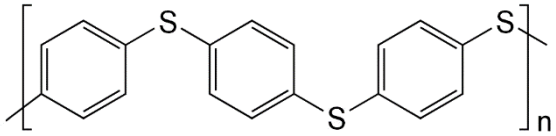
Review of state of the art sizing materials

Matrix: PEKK and PPS →

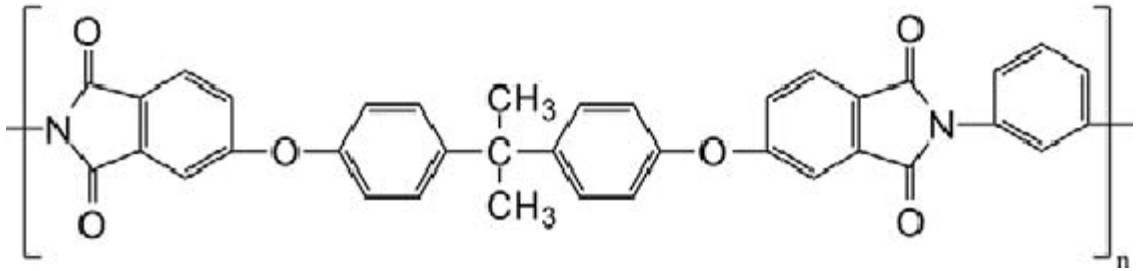
PEI and PSF sizing



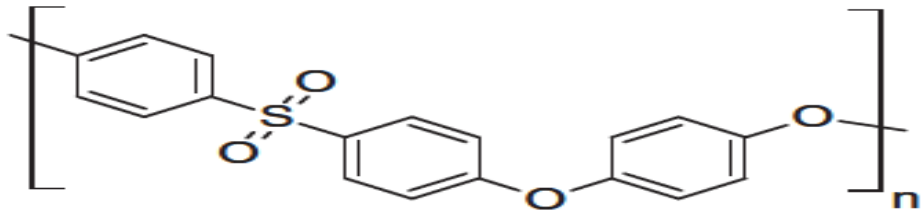
PEKK



PPS

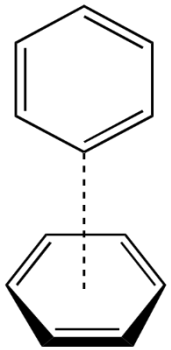


PEI

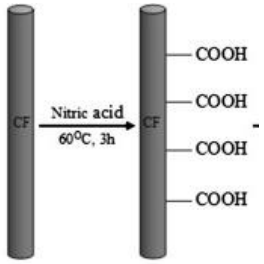


PSF

Due to the miscible feature of PEI,PEEK, PSF. PEEK chains can diffuse into the sizing layer at high processing temperature and pressure



Π Interactions between the CF and the aromatic structure of the sizing and matrix



The oxidized CF can form hydrogen bond with the polar groups of the sizing and matrix

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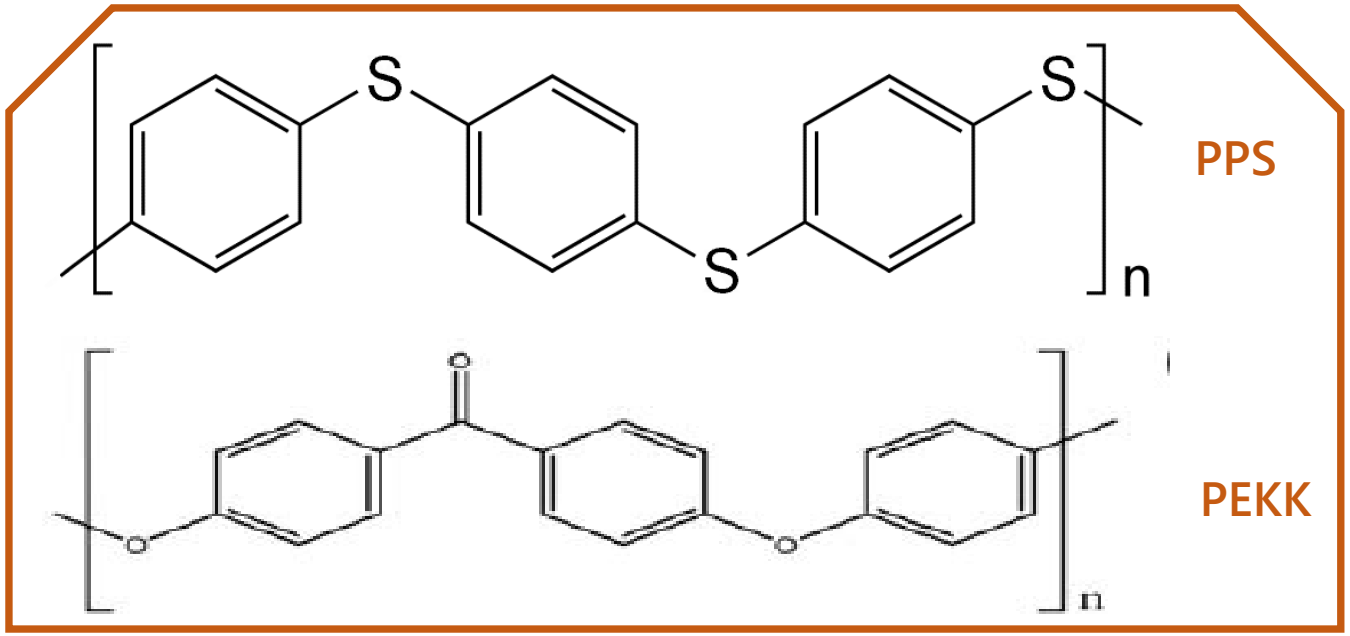
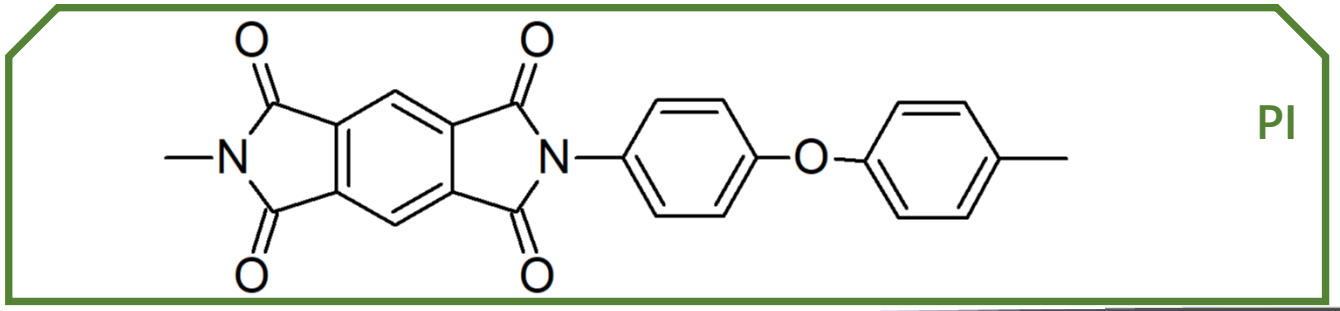
Review of state of the art sizing materials

Matrix: PPS and PEKK ⟶ PI sizing





Due to the miscible feature of PI,PPS and PEEK. PEEK and PPS chains can diffuse into the sizing layer at high processing temperature and pressure

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Review of state of the art sizing materials

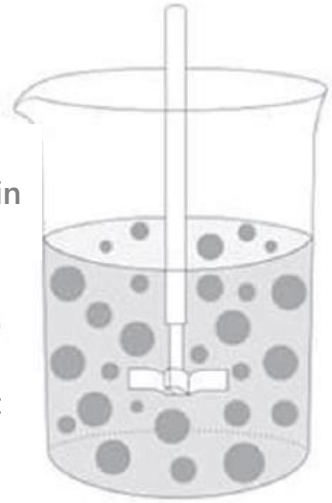
PEI and PSF sizing preparation

PEI and PSF disolved in NMP

Solution

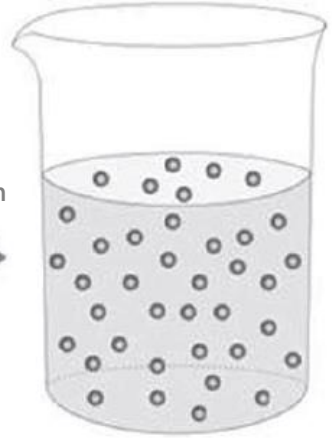
Organic solution:
PEI and PSF dissolved in
$CHCl_3$+surfactant

Aqueous solution:
Stabilizer in water



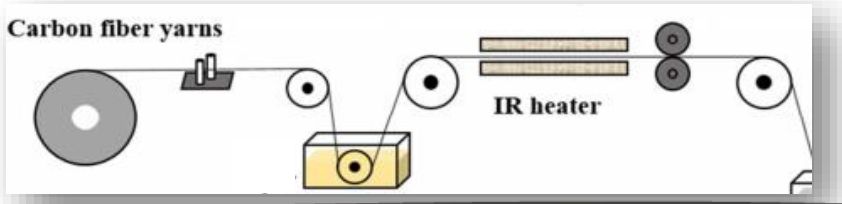
Step 1

Solvent evaporation



Step 2

Emulsion



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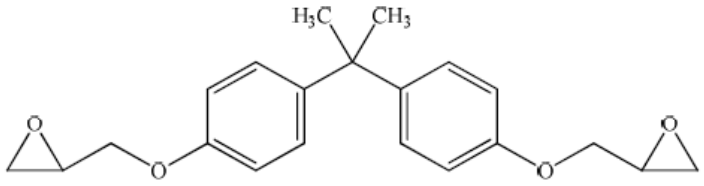
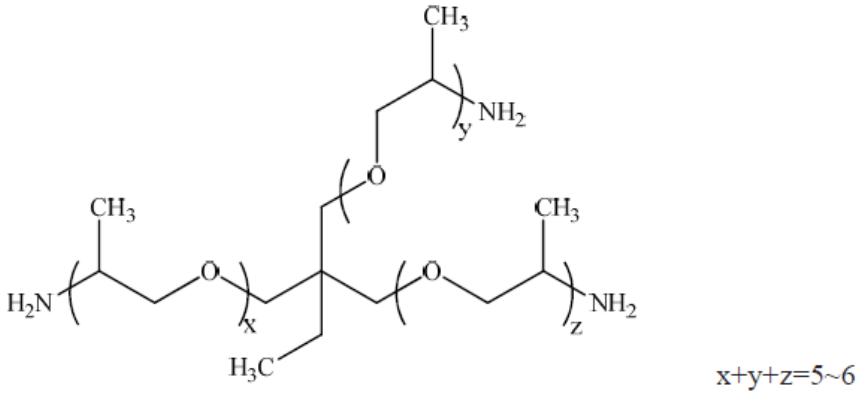
Matrix: Epoxy → Epoxy sizing



Diglycidyl ether of bisphenol A



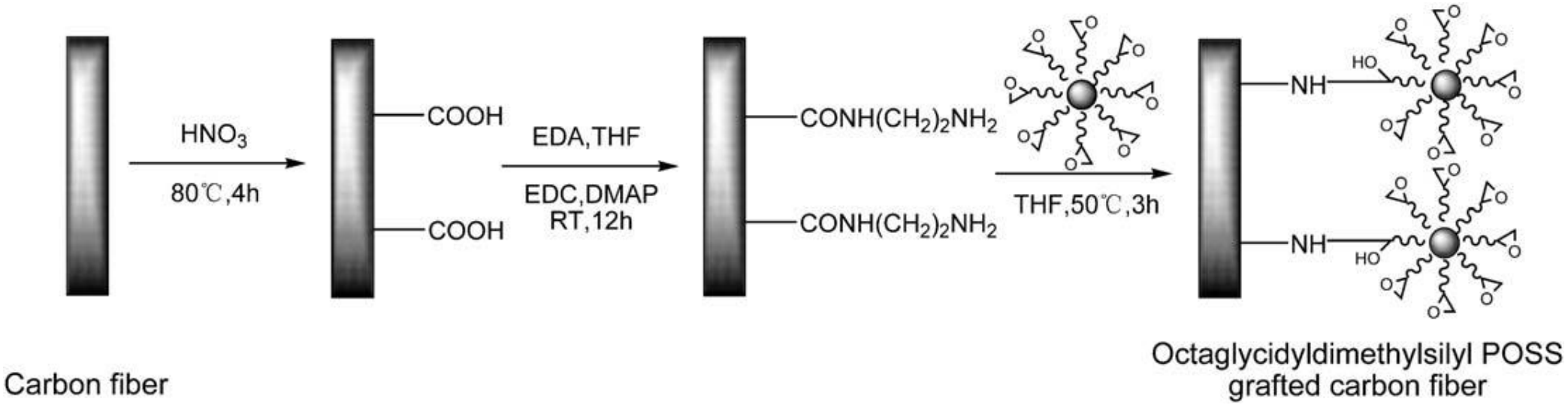
x+y+z=5~6

Polyetheramine

Different proportions of epoxy DGEBA and hardener will be dissolved in acetone to prepare the sizing material

Review of state of the art sizing materials

Matrix: Epoxy ⟶ POSS sizing



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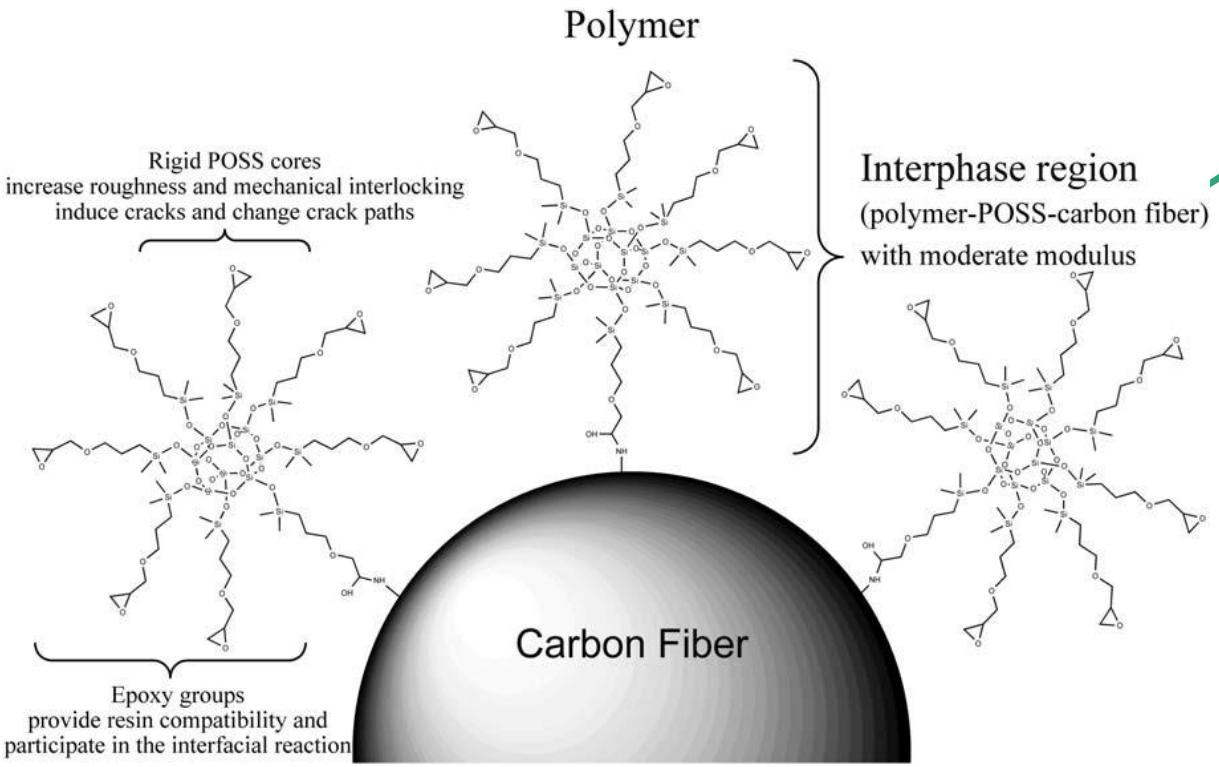
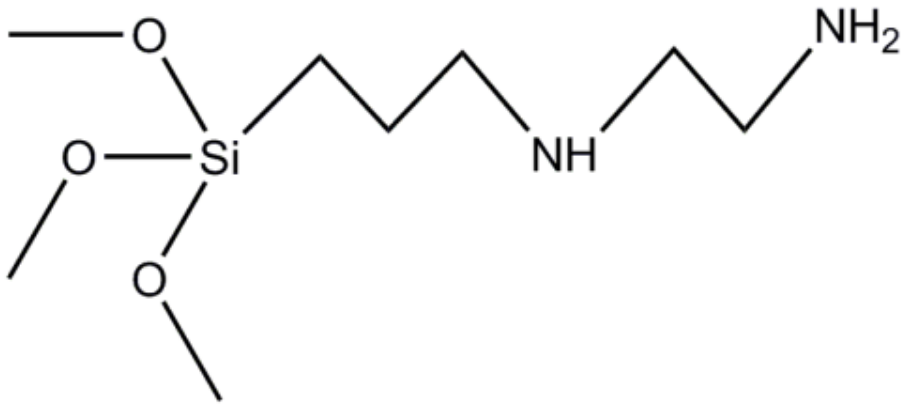
Matrix: Epoxy ⟶ POSS sizing



The POSS bonded the carbon fibers and matrix with strong chemical bonding through reacting with the reactive groups on the carbon fiber surface and the hardener in the matrix system, respectively

Review of state of the art sizing materials

Matrix: Epoxy → Silane sizing

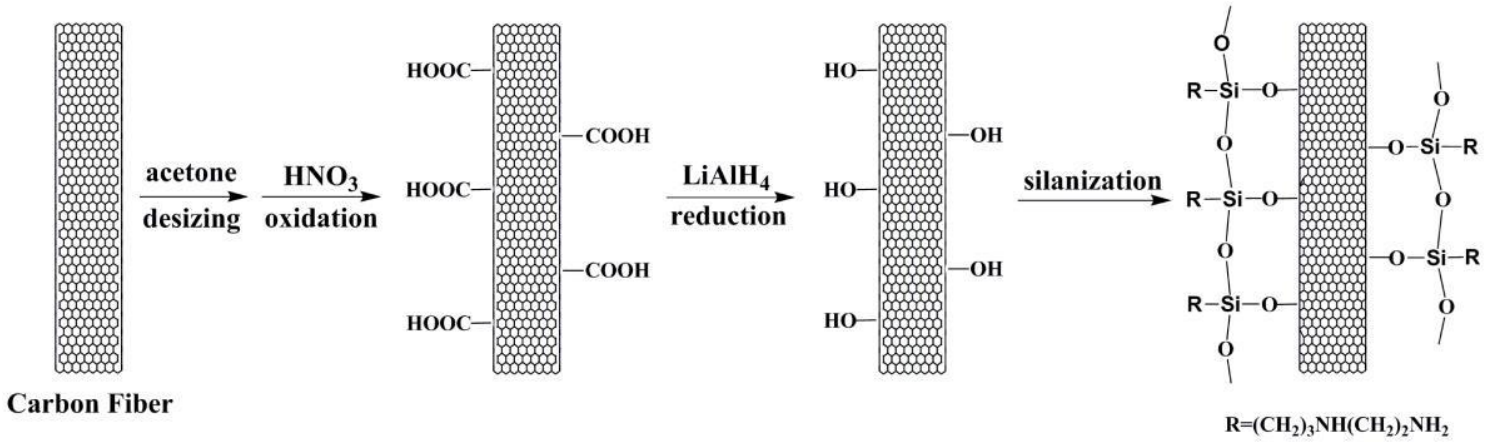


Structure of [3-(2-Aminoethyl) aminopropyl] trimethoxysilane

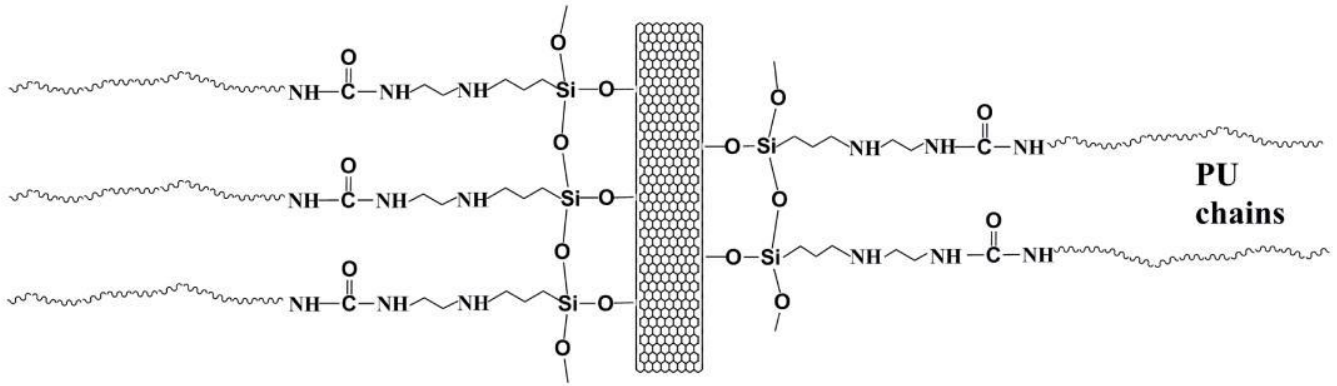
The bifunctional groups of silane coupling agents can respectively react with fillers and matrix thereby forming a chemical bridge to improve the interfacial adhesion between them

Review of state of the art sizing materials

Matrix: PU →
Silane sizing



Possible mechanism between CFs with PU matrix



Review of state of the art sizing materials

Plasma treatment

Low pressure plasma

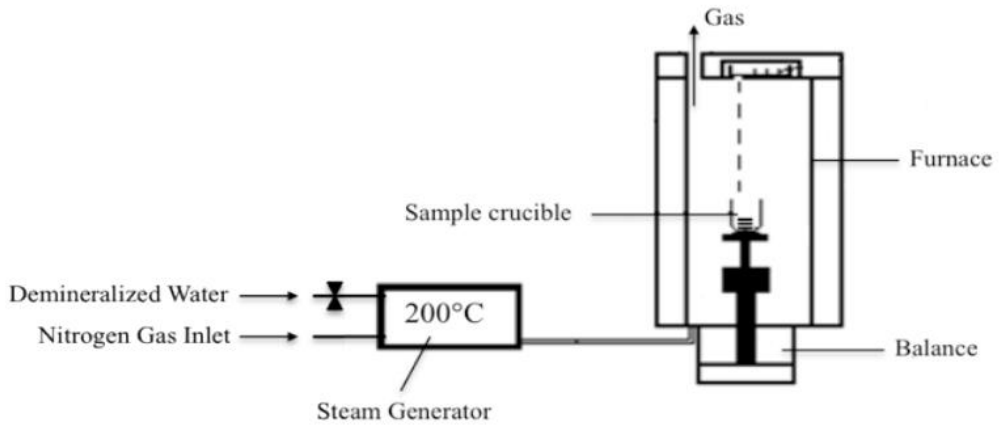
It will be used as a novel sizing base to increase rCF-matrix interfacial adhesion

-> Versatile treatment options while preservating of the material properties

-> have been proven to form a number of different functional groups for bonding (such as hydroxyl, carbonyl & carboxyl)

Review of state of the art sizing materials

Recycling by steam water thermolysis



Carbon fibres will be thermal treated in order to modify the surface state by applying an experimental plan using several parameters such as water amount, atmosphere chemistry (N2, O2, catalysts), residence time, temperature

Assessment and characterization of the recycled fibres with the new sizing

Characterization of the rCF and the new resized CF

The morphologies of virgin fibres, recycled carbon fibres and the resized fibres will be studied using:

1. Scanning Electron Microscope (SEM)
2. Water angle on fibre will be performed using dataphysics specific equipment
3. Atomic Force Microscopy (AFM) in order to study the topographies of the recycled carbon fibre and the resized recycled
4. X-ray photoelectron spectroscopy (XPS) this technique along with Fourier-transform infrared spectroscopy (FTIR) will help determine the new functionalities on the CF surface and hence, the level of activation of the carbon fibre after the applied treatments
5. Microbond test will be used to determine IFSS of carbon fibre/ matrix

Summary

It has been identified the requirements for the new sizing
It has been proposed the different approaches for the sizing of recycled carbon fibre

Next steps

Recycling of CF
Applications of the new sizing onto the rCF

Thanks for your attention

Merci pour votre attention

Gracias por su atención