HANNOVER MESSE 2022

TYRE4BUILDINS

Fibre-Reinforced Aerogel Composites from Mixed Silica

Pedro Silva – pedro.silva@student.qui.uc.pt
Paulo Santos - pfsantos@dec.uc.pt
Luísa Durães - luisa@eq.uc.pt

HANNOVER MESSE

1 2 9 0
UNIVERSIDADE D COIMBRA

Tyre4BuildIns scope

Aim

To produce aerogel composites made of silica and recycled rubber sols, reinforced with fibers

What for?

To be applied in building insulation

But →

- **Why tyres?**
- **Why aerogel?**
- **Why BuildIns?**

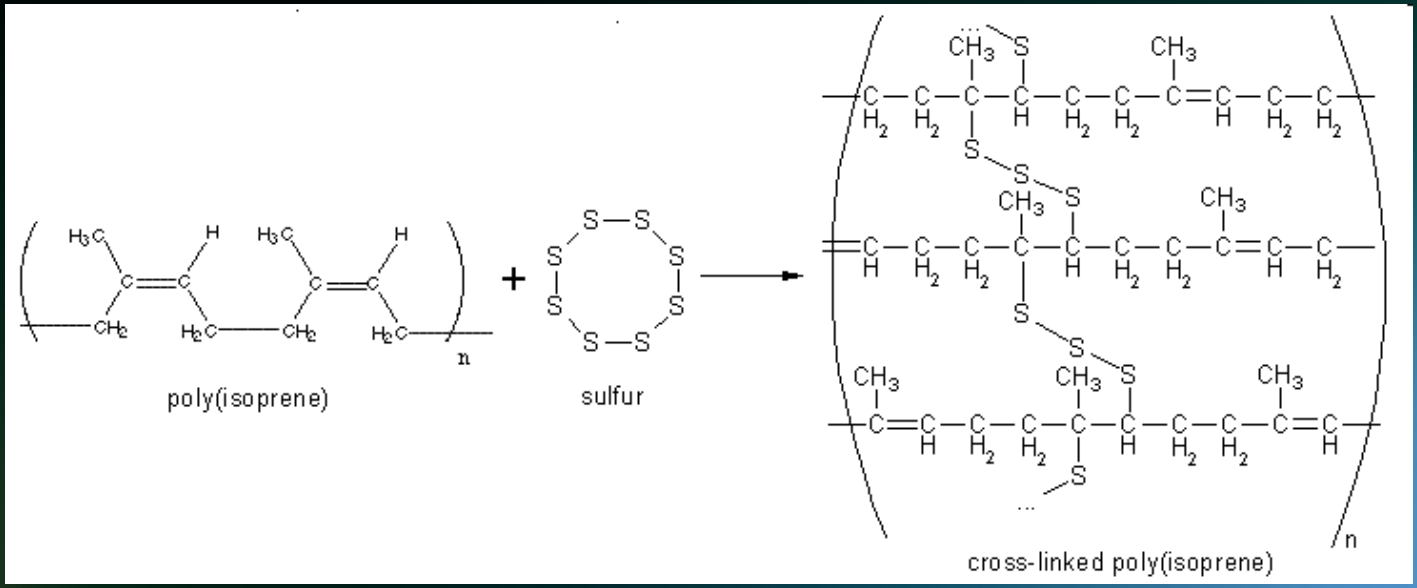
Why tyres?

Around **1 billion** waste tyres are generated worldwide every year

The number of tyres being discarded as end-of-life tyres continuously increased over the last decade

The Tyre Problem

The rubber from tyres is a crosslinked polymeric chain, which makes it very difficult to reprocess or degrade.

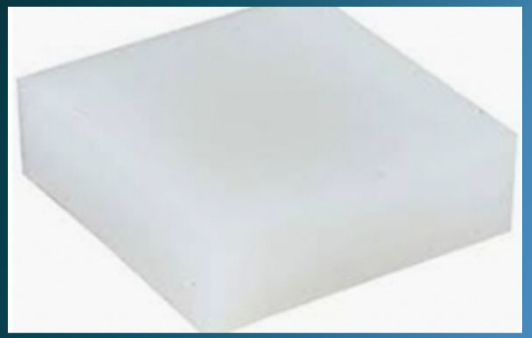


Furthermore, the short textile tyre fibers are composed of a mixture of different materials that cannot be easily recycled.

Alternatives to its disposal in landfills must be found!

Why Aerogels?

- Aerogels are often dubbed “material of the future” by the media
- They are **nanostructured materials** that can be tailored to have a plethora of interesting qualities, such as:
  - High surface areas - 400-1000 m2/g
  - Low densities - 30-200 kg/m3
  - Low heat conductivity - 12-20 mW/(m K)
  - Transparency
  - And more



Why Aerogels?

- Previous studies showed the possibility of incorporating tyre components into silica aerogels.
- This could be a feasable way to incorporate recycled tyre rubber into a **high-value product** with **real world applications**.

Why buildIns?

- Buildings are responsible for 40% of the EU energy consumption, and for 36% of the energy related greenhouse gas emissions.
- Almost 75% of the buildings in the EU use energetically inefficient insulation
- Many antique buildings are not compatible with the usual bulky insulation used.

Why buildIns?

The development of the recycled rubber aerogels yielded interesting characteristics such as:

- Thermal insulation
- Sound insulation
- Low densities
- Good mechanical properties
- Hydrophobicity

All of which are interesting properties for **home insulation materials** to have

How does rubber and aerogel work together?

The interesting characteristics offered by the tyre components can be combined with the interesting characteristics of aerogels in order to produce a material that is fit for insulation purposes

Thats the goal of Tyre4BuildIns!

Essentially we're working on finding the best characteristics of each component and technology, as well as ways to sinergize them.

Brittle silica aerogel

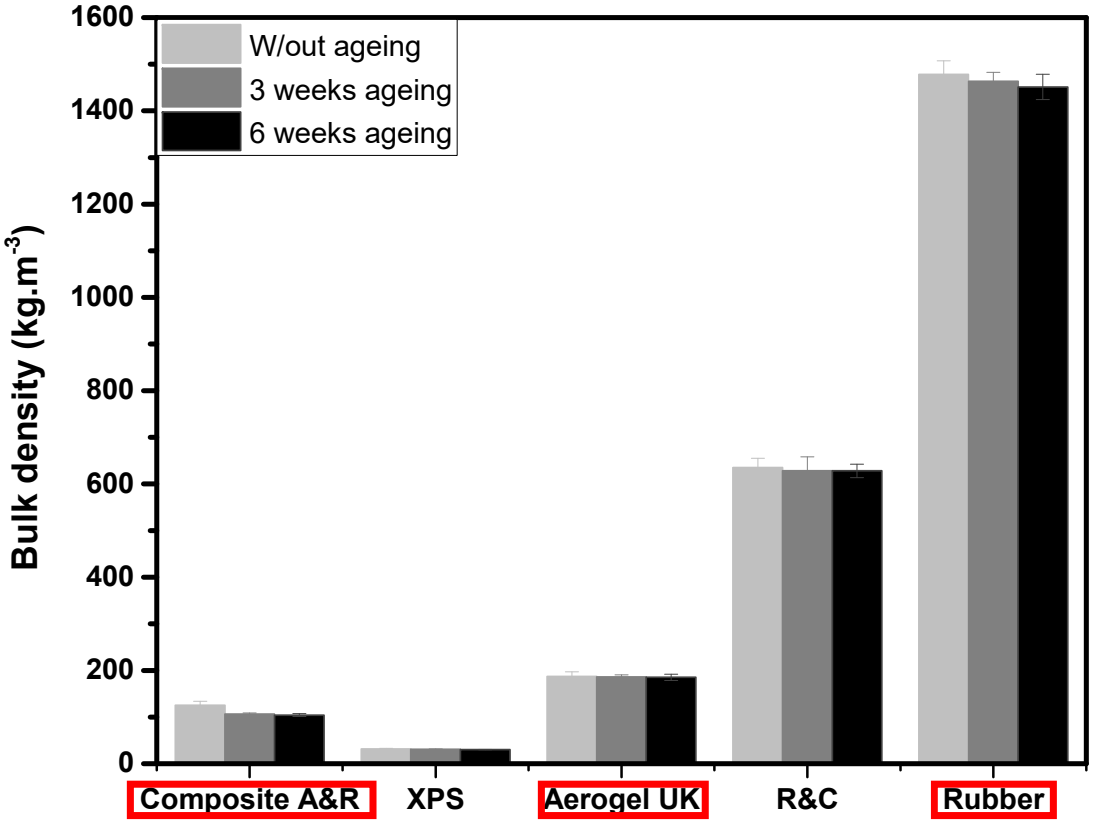
+

Flexible recycled tyre rubber

=

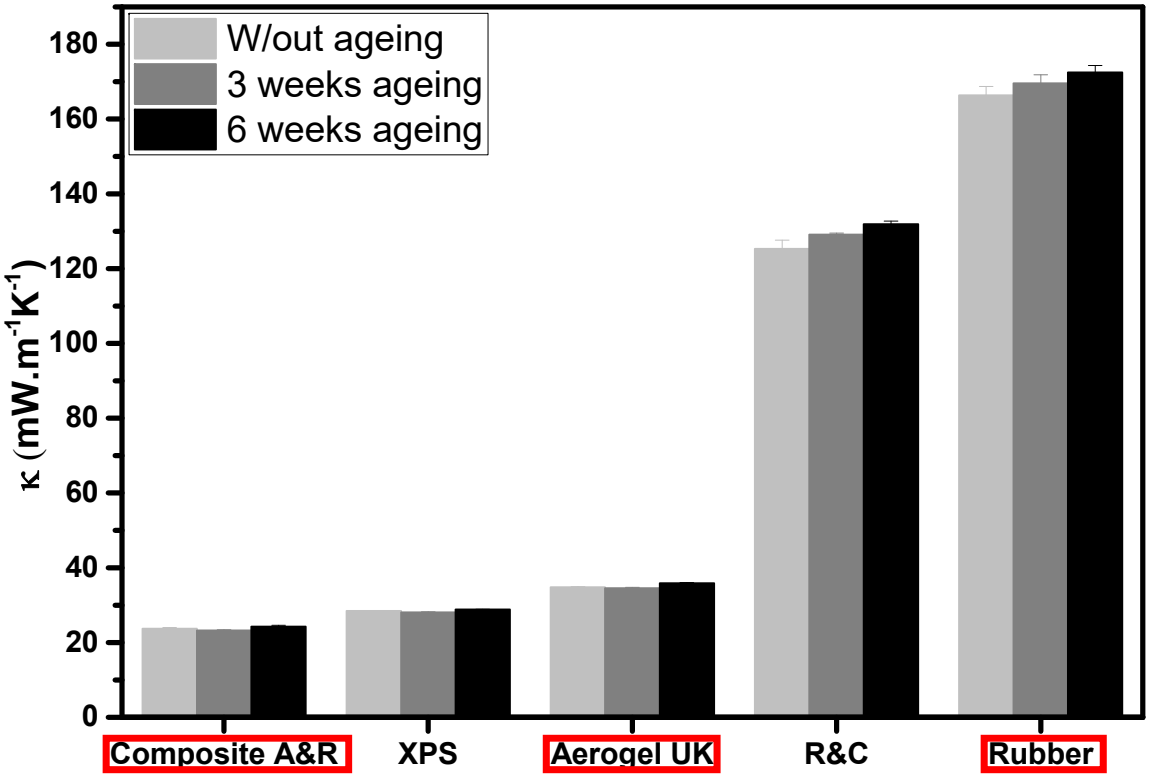
Sturdy aerogel

Bulk Density



A&R – aerogel & rubber
XPS – expanded polystyrene
R&C – Rubber & cork

Thermal Conductivity

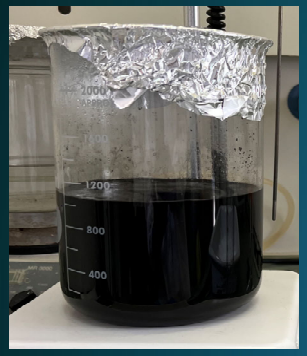


A&R – aerogel & rubber
XPS – expanded polystyrene
R&C – Rubber & cork

But how is it done?

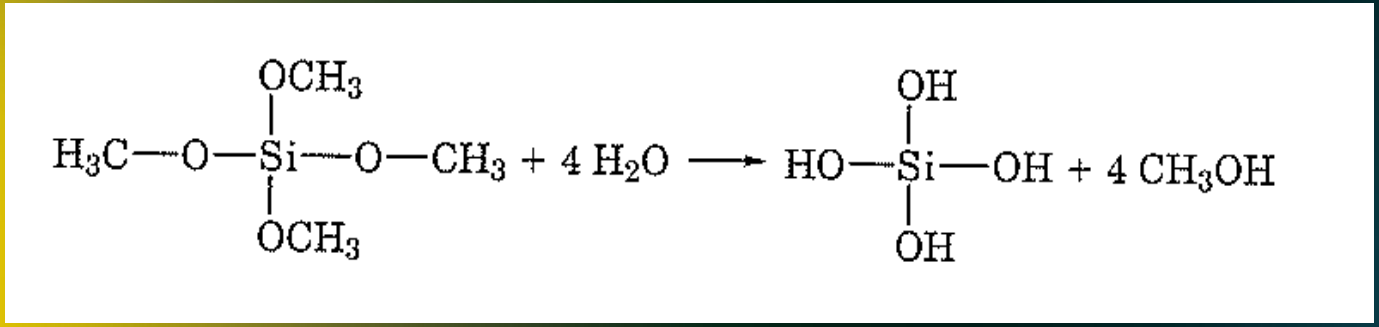
We need a rubber sol, that means, a colloidal suspension of desintegrated tyre rubber and silica precursors.

The rubber is pre-treated with peracetic acid so that it can form a stable colloidal solution.



How is it done?

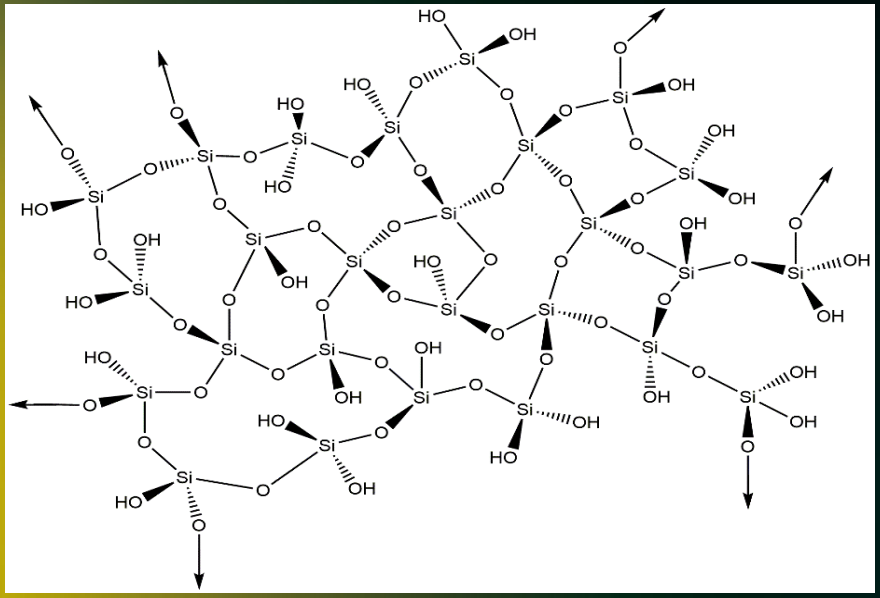
Next, the silica precursors are added into the sol and are given time to hydrolyse. The peracetic acid helps by making this step faster.



The hydrolysed precursors then suffer condensation, and produce colloidal silica particles

How is it done?

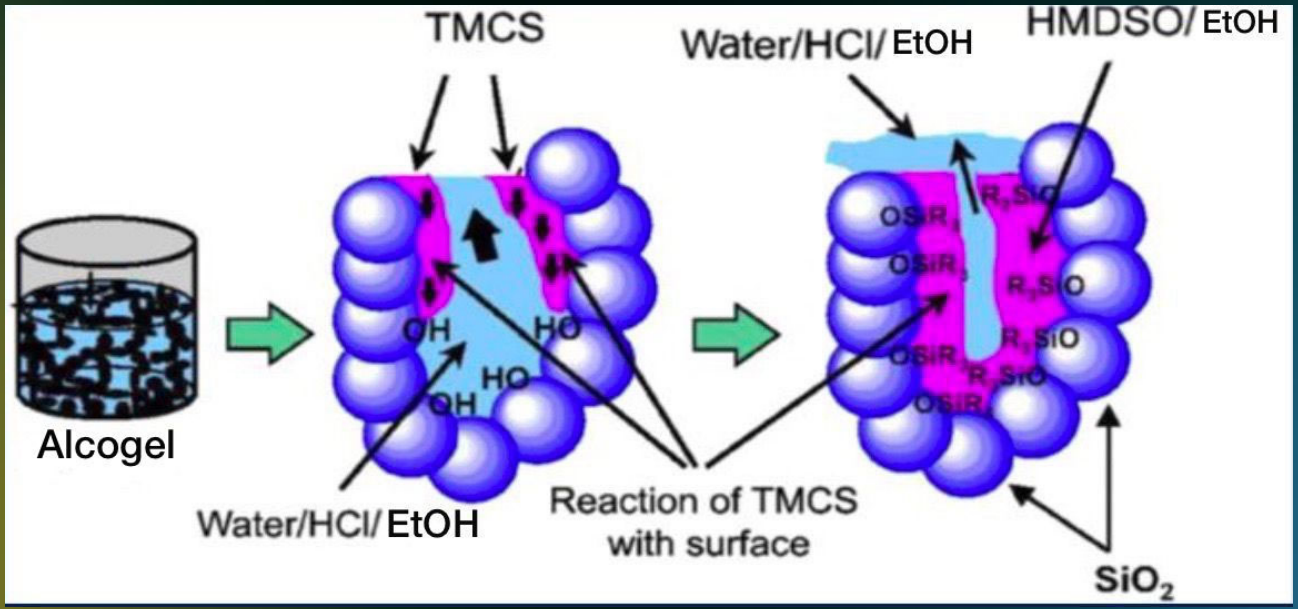
After the sol is formed, it is subjected to a pH change, through the addition of a base. This promotes the formation of a network of silica, transforming it in a gel.



The gel formed is then left to age, giving time to strengthen and develop its structure.

How is it done?

Then the modification step, which is responsible for making the gel hydrophobic.
This makes it less vulnerable to shrinking as it dries (lower surface tensions)



The hydrophobicity helps with the stability of the material in ambient humidity as well

How is it done?

Finally, the modified gel is dried at temperatures of 100-150 ^{o}C, yielding the final product.

Process round up

1. Used Tyre

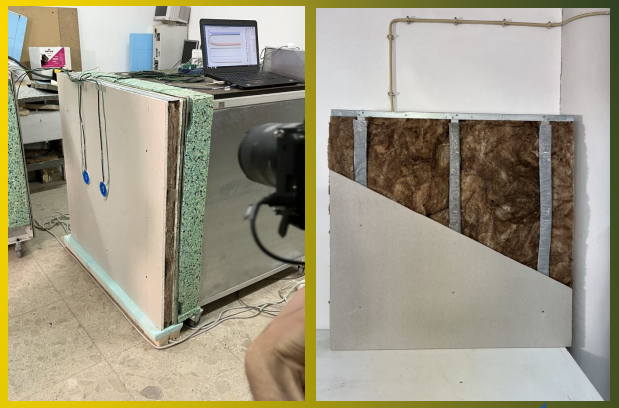
2. Recycled Rubber

3. Textile Recycled Tyre Fibers

4. Rubber Sol (Dissolved Rubber)

5. Rubber Silica Gel

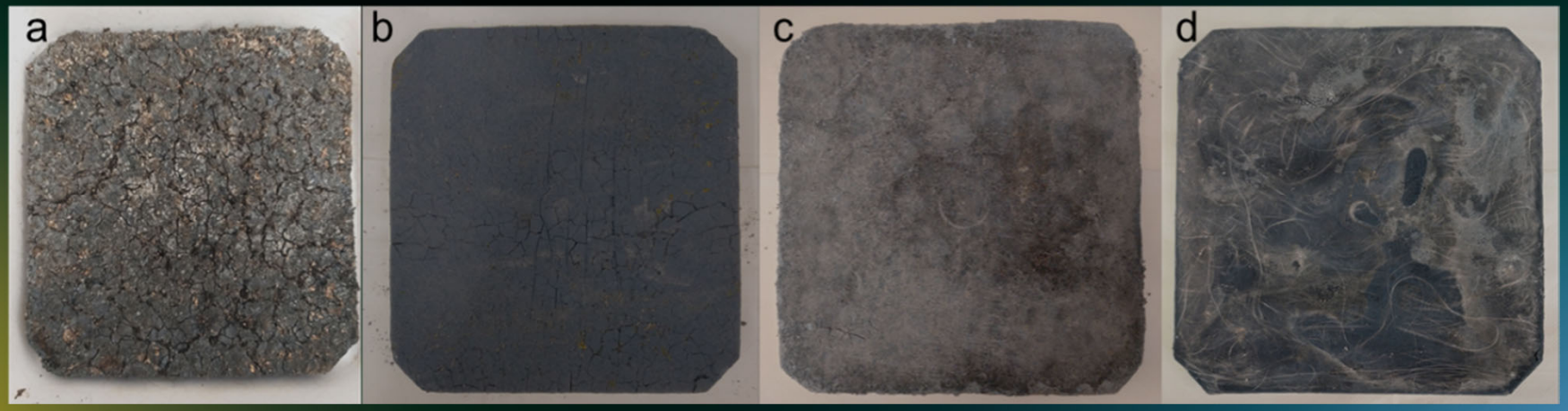
6. Aerogel Samples



7. Insulation

#UC IN #HM22

Scale up: panels with 21.5 x 21.5 x 1.5 cm3

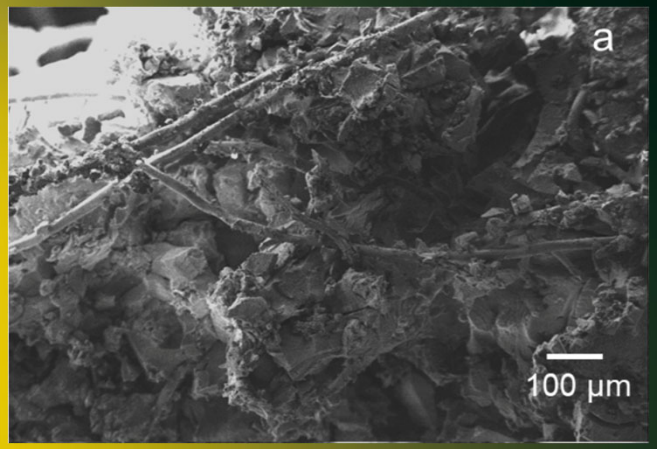


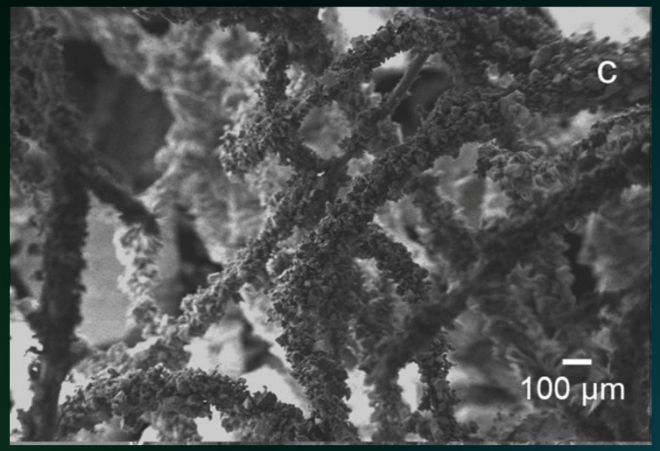
Recycled tyre fibers | Polyester fibers | Silica fibers | Glass wool

Bulk Density	**197.9** kg.m-3	**115.0** kg.m-3	**100.3** kg.m-3	**120.1** kg.m-3
Thermal conductivity	**28.1** mW.m-1.K-1	**16.4** mW.m-1.K-1	**23.2** mW.m-1.K-1	**28.7** mW.m-1.K-1
Loss of mass due to heating	**42.5** %	**3.4** %	**1.9** %	**0.8** %
Contact Angle	**125** º	**131.7** º	**134** º	**137.5** º

Current developments

The tyre fibers are an interesting material but as is, they don’t get incorporated very well into the gel matrix.





SEM images depicting:
a) composite with tyre fibers
c) Composite with polyester fibers

The aim of the Project right now is to find ways to incorporate these fibers and obtain even better properties.

Real world applications

- **Thermal bridges insulation** in Lightweight Steel Framed (LSF) buildings – increase thermal resistance up to 77%
- **Acoustic conditioning** – noise reduction coefficient of 0.41
- **Retrofitting** – incorporate efficient insulation in old buildings
- **Adsorb oils** and other impurities from waste water

HANNOVER MESSE 2022

THANK YOU!

Research co-funded by European Regional Development Funds (ERDF), through the Operational Programme for Competitiveness and Internationalisation — COMPETE2020, and by national funds through FCT—Foundation for Science and Technology (Portugal), under the scope of the project POCI-01-0145-FEDER-032061 – TYRE4BUILDINS: Recycled Tyre Rubber Resin-Bonded for Building Insulation Systems Towards Energy Efficiency, developed by University of Coimbra

Project's website
www.tyre4buildins.dec.uc.pt

Project's Email:
tyre4buildins@dec.uc.pt

THANK YOU!

Any questions?

HANNOVER MESSE

1 2 9 0
UNIVERSIDADE D
COIMBRA