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Development of a new insulating bio-based composite made from sunflower stalk aggregates and chitosan: Thermal, mechanical and acoustical characterizations

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HAL Authorization

Development of a new insulating bio-based composite made from sunflower stalk aggregates and chitosan: Thermal, mechanical and acoustical characterizations

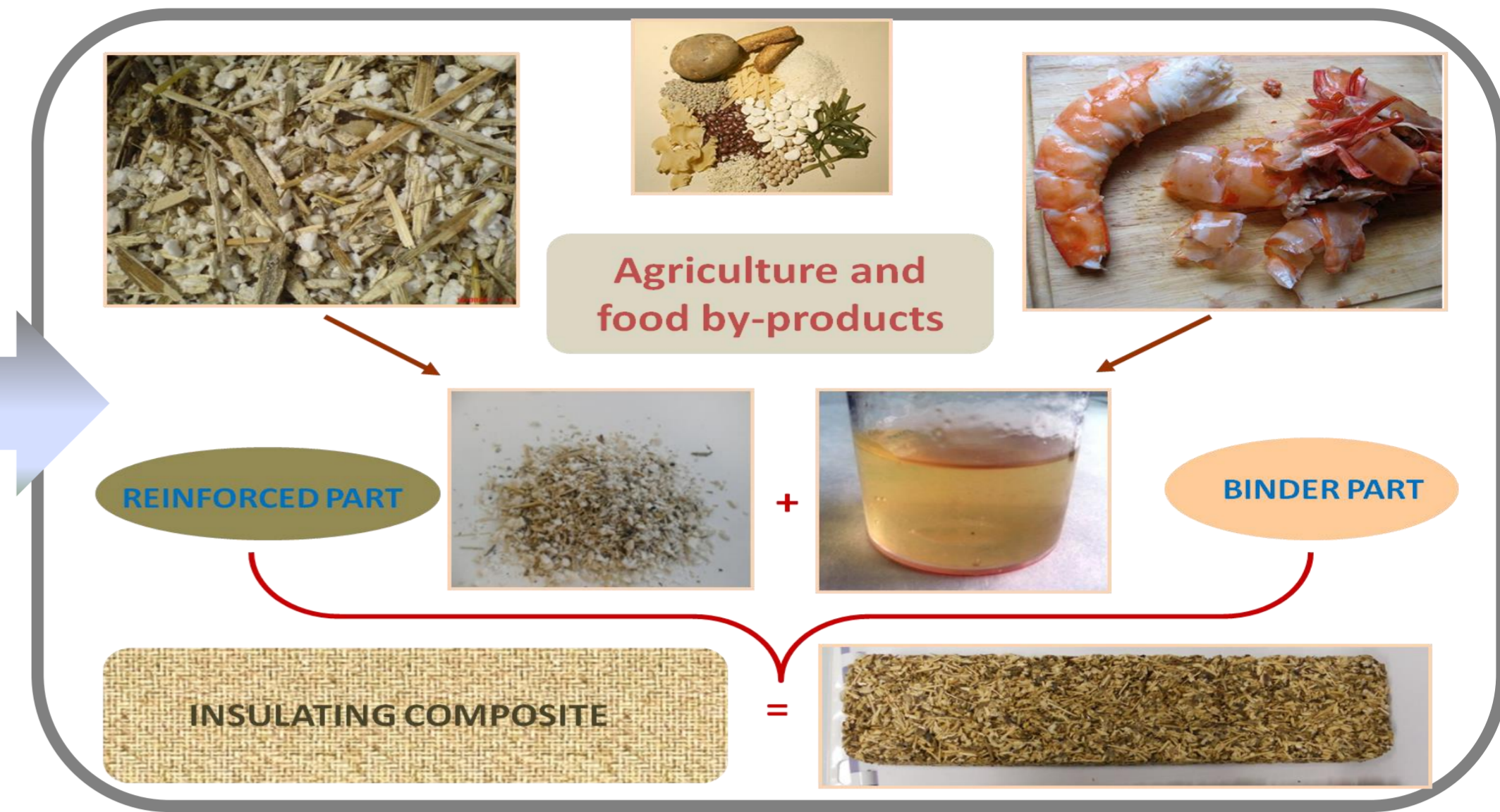
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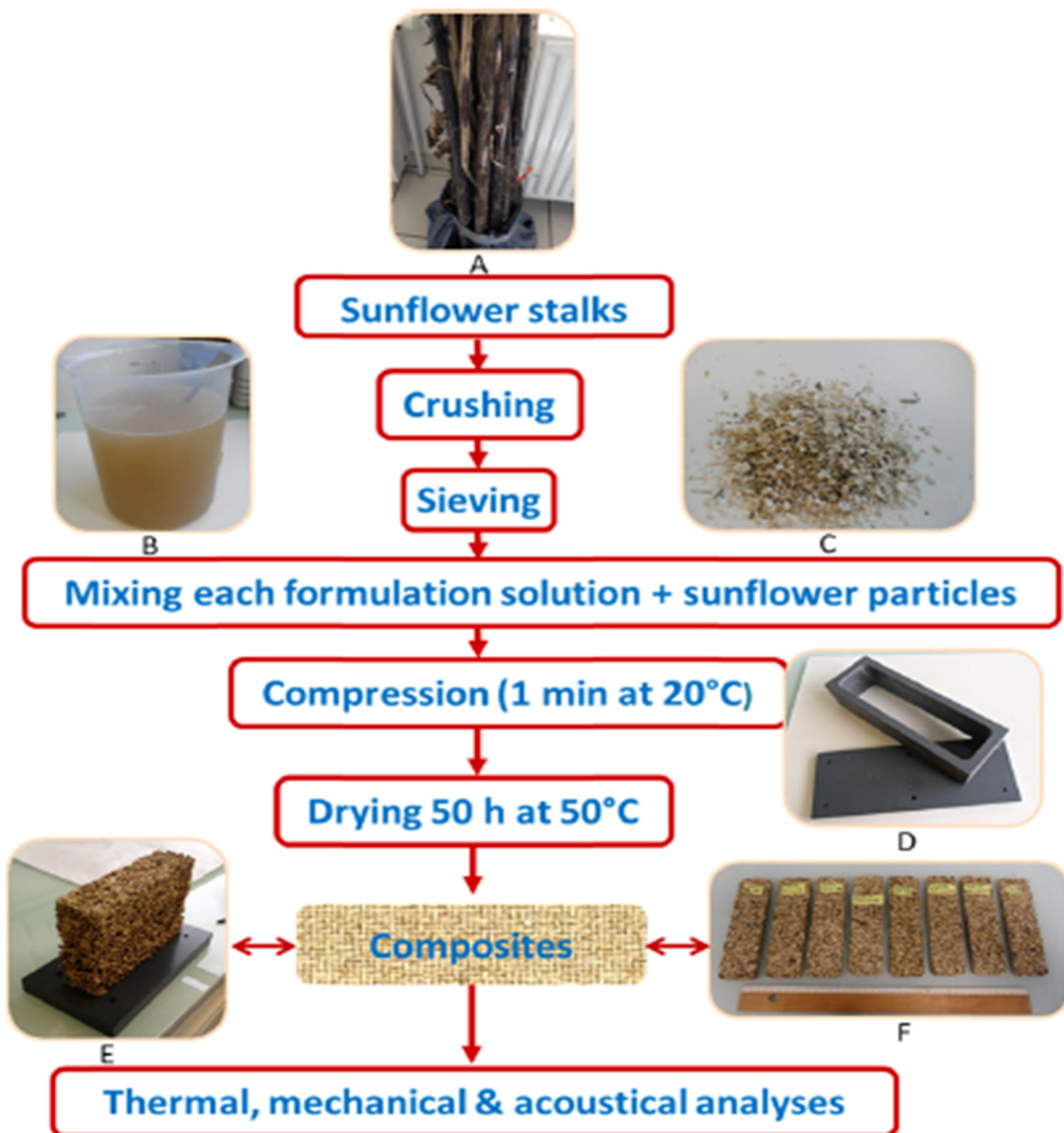
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Introduction

The ANR DEMETHER project certified by Cereal Valley and Viaméca has for objective to use sunflower stem by-products as reinforcement of panels to insulate existing buildings. The originality of this approach consists in using natural binders such as chitosan in the aim to obtain competitive bio-based materials for their thermal, mechanical, acoustical, economical and environmental performance.



Composites Production



Process of obtaining agro-composite from sunflower stalks and chitosan. (A) sunflower stalks (LG5474), (B) chitosan solutions at 2-9% (w/v), (C) sunflower stalk particles (1-6 mm), (D) PVC mold, (E) composite sunflower/chitosan obtained for compressive analysis, (F) composites obtained for the tensile analysis.

Process of Characterization

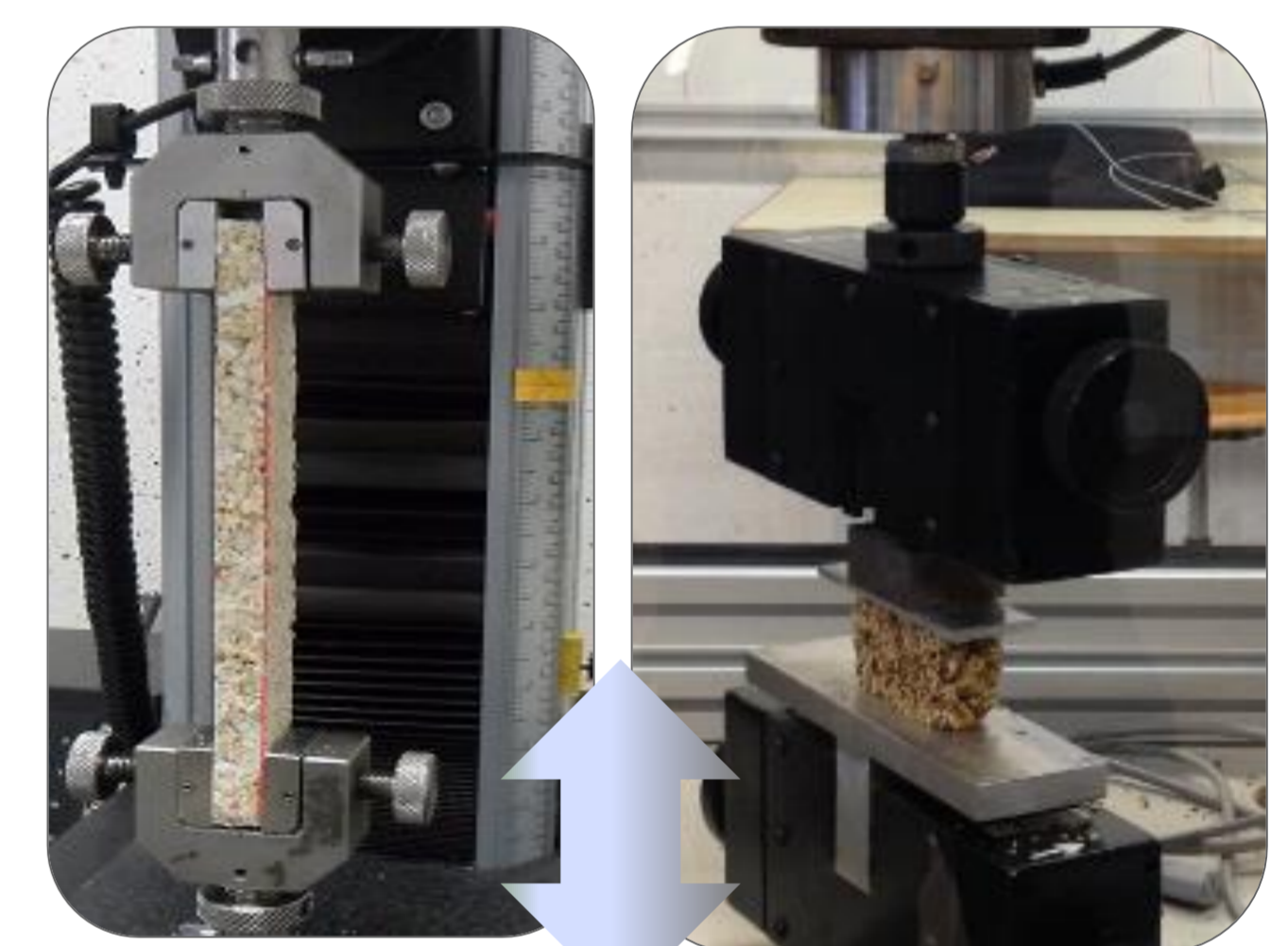
An experimental design was established to find the optima parameters which influence the thermal and mechanical properties of the bio-based composite: the size grading of particles, the ratio chitosan/sunflower particles and the compaction pressure during manufacture :

Area of variations of the operating parameters.

Level	Particle size (mm)	Ratio (%)	Compaction pressure (10 ⁻³ MPa)
+1.68	6.30	15.3	574
+1	5.00	13.3	373
0	3.12	10.0	156
-1	2.00	6.6	32
-1.68	1.60	4.3	1



Heat conductivity (κ) determination by **Hot Wire method** (Neotim FP2C)



Young modulus (E') and maximum stress (σ_{max}) determination by **Tensile and Compressive analysis** (Zwick/Roell)



Sound absorption coefficient (α) determination by **Impedance Tube method**

Results

Results of the experimental design obtained on both mechanical and thermal properties of composites chitosan/sunflower stalks aggregates, as a function of the applied compaction pressure, the size of sunflower particles and the ratio chitosan/sunflower.

	Optimal properties	Compaction (10 ⁻³ MPa)	Size of particles (mm)	Ratio (w/w) chitosan/sunflower (%)
Tensile mode	$E' = 250$ MPa	574	3.1	15.38
	$\sigma_{max} = 2$ MPa	574	6.3	^a
	$\kappa = 0.056$ W m ⁻¹ K ⁻¹	574	6.3	4.38
Compressive mode	$E' = 25$ MPa	574	6.3	15.38
	$\sigma_{max} = 2.6$ MPa	574	6.3	15.38
	$\kappa = 0.058$ W m ⁻¹ K ⁻¹	1	6.3	4.38

^a No significant effect was observed.

- Bio-based composite = thermal insulator ($\kappa = 0.06$ W.m⁻¹.k⁻¹)
- Bio-based composite: σ_{max} in tensile mode $\approx \sigma_{max}$ in compression mode ≈ 2 MPa
- Mechanical performances are superior to the specification of the building in Europe (DIN 4108-10 maximum stress of **0.05 MPa**)
- Confirmation of chitosan's potential to be employed as a linker to bond plant particles
- Low acoustical performance of the bio-based composite $\alpha = 0.2$ in the frequency of 2500-4000 Hz

Conclusions & Perspectives

- Composites having a heat conductivity of **0.06 W.m⁻¹.k⁻¹** and a maximum stress of **2 MPa** were obtained with a ratio of chitosan of 4.3 % (w/w) and a size grading of particles of 6.3 mm. These mechanical and thermal performance are superior to the other insulating bio-based materials available on the market.
- Study the aging of the bio-based composites, as a function of temperature, ultra-violet radiations and relative humidity, is a perspective.

Acknowledgements

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