



HAL
open science

Insulation blocks made from sunflower pith with improved durability properties

Vincent Novi, Laurent Labonne, Stéphane Ballas, Thierry Véronèse, Philippe Evon

► **To cite this version:**

Vincent Novi, Laurent Labonne, Stéphane Ballas, Thierry Véronèse, Philippe Evon. Insulation blocks made from sunflower pith with improved durability properties. 5th International Conference on Bio-Based Building Materials (ICBBM 2023), Jun 2023, Vienna, Austria. <hal-05003040>

HAL Id: hal-05003040

<https://hal.science/hal-05003040v1>


Submitted on 14 Apr 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization



LCA
LABORATOIRE DE CHIMIE
AGRO-INDUSTRIELLE


AM
AGROMAT
R&D à l'échelle industrielle



Insulation blocks made from sunflower pith with improved durability properties

V. Novi¹, L. Labonne¹, S. Ballas², T. Véronèse² and **Philippe Evon**^{1*}

¹Laboratoire de Chimie Agro-industrielle, University of Toulouse, France
²Ovalie Innovation, Auch, France

* Philippe.Evon@toulouse-inp.fr

INP Ensiacet **INRAE** 


GOUVERNEMENT
Liberté
Égalité
Fraternité

FRANCE
RELANCÉ



Introduction

OVALIE
INNOVATION

- **“France Relance” recovery plan in partnership with Ovalie Innovation.**
- Project duration: 24 months (end November 2023).
- Main objectives of the project:
 - **Fractionating sunflower stalk into bark and pith fractions.**
 - **From pith specifically, developing innovative thermal insulation panels, and industrial absorbents for various pollutants.**
- Working methodology:
 - ◆ Isolating the sunflower pith from stalk through a **dry fractionation scheme**.
 - ◆ Making innovative bio-based thermal insulation materials from pith.
 - ◆ Characterizing each formulation produced to optimize the final product.


INP Ensiacet **INRAE** 

2

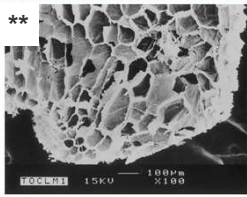

 Laboratoire de Chimie Agro-Industrielle

Photographs of sunflower pith particles

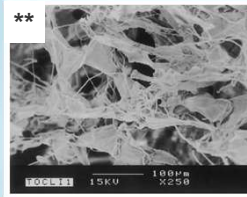
- Honeycomb structure:
 - ◆ Natural alveolar structure.
 - ◆ Very low density ($\approx 25\text{-}30\text{ kg/m}^3$ tapped density).
 - ◆ **Enhanced thermal conductivity.**



* 0.0 1.0 cm









** 15KV 100µm X100



** 15KV 100µm X2250

* Knapik, E., & Stopa, J. (2018). Fibrous deep-bed filtration for oil/water separation using sunflower pith as filter media. *Ecological Engineering*, 121, 44-52, <https://doi.org/10.1016/j.ecoleng.2017.07.021>.
 ** Marechal, V., & Rigal, L. (1999). Characterization of by-products of sunflower culture: commercial applications for stalks and heads. *Industrial Crops and Products*, 10 (3), 185-200.





3


 Laboratoire de Chimie Agro-Industrielle





Chemical composition of sunflower pith

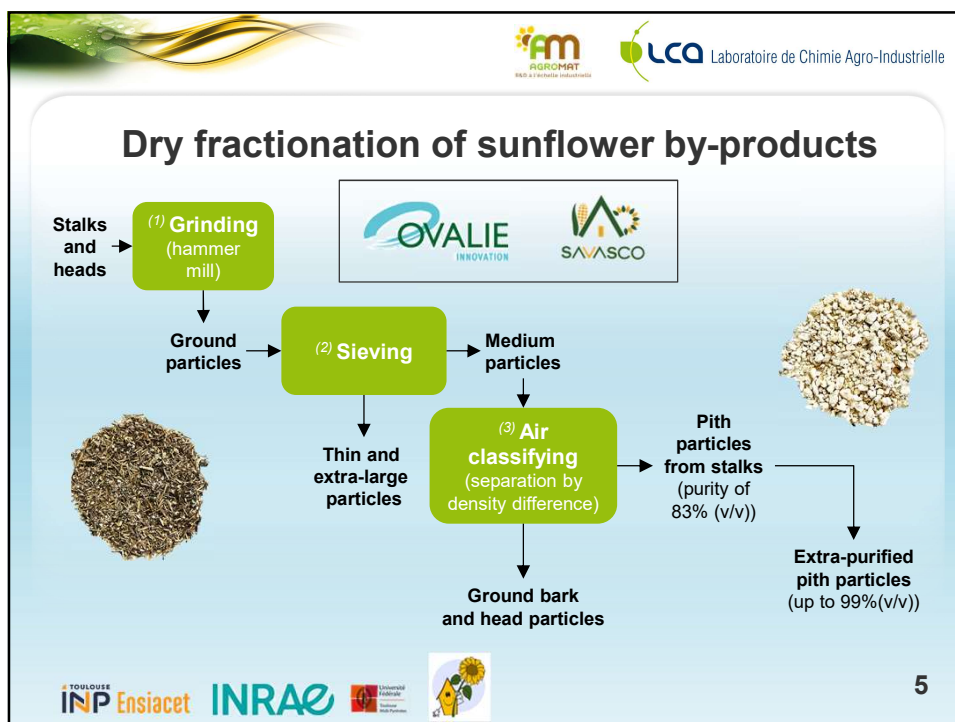
- Chemical composition (% of dry matter)*:
 - ◆ Natural fibers → ADF-NDF method of Van Soest and Wine (1967, 1968).



Chemicals	Content (%)
Minerals	16.0±0.1
Cellulose	45.4±0.0
Hemicelluloses and pectins	22.0±0.0
Lignins	3.2±0.0
Water-soluble compounds	18.6±0.3

NATURAL FIBRES (70.6%)

* Ratsimbazafy, H. H. (2022). *Évaluation du potentiel de co-produits agricoles locaux valorisables dans le domaine des matériaux de construction (PALOMAC)* (Doctoral dissertation, Université Paul Sabatier, Toulouse, France).






4









 Laboratoire de Chimie Agro-Industrielle

Insulation block from pith particles



- Low-cost compression moulding process with very low hydraulic pressure (100 kPa or $\approx 1 \text{ kgf/cm}^2$) applied at room temperature during 90 s.
- Starchy binder with physical curing as natural adhesive.
 - ◆ Different starches (pea, wheat, potato) with variable amylose contents.
 - ◆ Expected reduced hydrophilic character for the richest starch in amylose.
- Three-step process:
 - ◆ **Dissolving** starch in water.
 - ◆ **Mixing**, and then **moulding**.
 - ◆ **Drying** in a ventilated oven.
- Applications in the building sector:
 - ◆ 41-43 mW/m K thermal conductivity.
 - ◆ In the low range of conventional insulating materials.



Insulation blocks





6






Process optimization through three successive studies

- 1 Optimization of binder dilution in water and selection of optimal binder.
- 2 Optimization of binder ratio in proportion to the pith particles.
- 3 Coating of the optimized block as a water-proofing post-treatment.

7

1 Optimization of binder dilution and selection of optimal binder





- Starch: **Potato** (20% amylose), **wheat** (25%) and **pea** (35%).
- Range of binder dilution ($\% [w_{binder}/w_{water}]$):
 - ◆ 6.0%, 7.5%, 9.0% and 12.0%.
- Binder ratio fixed ($\% [w_{binder}/w_{pith}]$): **10%**.



Binder	Binder dilution (%)	A_w^* ($\text{kg}/\text{m}^2 \text{ s}^{0.5}$)	Water resistance	Density (kg/m^3)
Potato	6.0	$1.94 \pm 0.15 \cdot 10^{-1}$	2 out of 3	42.1
Wheat	7.5	$1.73 \pm 0.38 \cdot 10^{-1}$	1 out of 3	34.4
Pea	7.5	$1.70 \pm 0.26 \cdot 10^{-1}$	3 out of 3	35.4

* Adaptation from the NF EN ISO 15148 French standard (sponge test).

- Selection criteria:
 - ◆ Reduction in water absorption coefficient (A_w).
 - ◆ Increase in water resistance (i.e., number of test specimens remaining cohesive after sponge test).

8















② Optimization of binder ratio

- Starch selected: **Pea** (*i.e.*, the richest in amylose).
- Range of binder ratio ($\% [w_{binder}/w_{pith}]$):
 - ◆ 6%, 8%, 10%, 12% and 14%.
- Fixed binder dilution ($\% [w_{binder}/w_{water}]$): **7.5%**.
- Selection criteria :
 - ◆ Reduction in water absorption coefficient (A_w).
 - ◆ Increase in water resistance (*i.e.*, number of test specimens remaining cohesive).
 - ◆ Decrease in thermal conductivity (λ).
 - ◆ A compressive modulus of elasticity (E) close to that of expanded polystyrene (EPS) (883 kPa).

9










② Optimization of binder ratio

Material	Binder ratio (%)	A_w ($\text{kg/m}^2 \text{s}^{0.5}$)	Water resistance	λ (mW/m K)	E (kPa)	Density (kg/m^3)
Pea starch	6.0	N/A	N/A	N/A	N/A	N/A
	8.0	$2.10 \pm 0.23 \cdot 10^{-1}$	3 out of 3	41.5 ± 0.5	876 ± 45	35.3
	10.0	$1.90 \pm 0.14 \cdot 10^{-1}$	3 out of 3	42.5 ± 0.5	997 ± 123	35.9
	12.0	$1.87 \pm 0.16 \cdot 10^{-1}$	3 out of 3	42.5 ± 0.5	905 ± 64	36.7
	14.0	$1.46 \pm 0.18 \cdot 10^{-1}$	1 out of 3	42.5 ± 0.5	$1,236 \pm 20$	37.2
EPS	-	-	-	33.0 ± 0.5	883 ± 40	10.6

N/A : Not Available.

10








③ Coating of the optimized block (10% pea starch ratio)



- Hydrophobic agents tested:
 - ◆ Commercial bio-based aqueous solution: tannins?
 - ◆ Ethanolic pine resin solution.
- Optimal surface mass previously determined.

Hydrophobic agent	Mass concentration (g/L)	Surface mass of hydrophobic agent (mg/cm ²)
Bio-based aqueous solution	170.0	1.6
Ethanolic pine resin solution	100.0	6.7

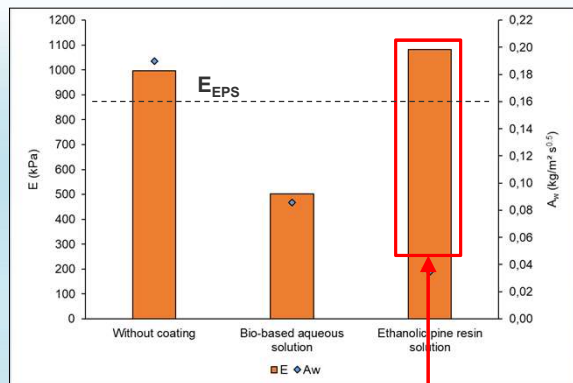
- Selection criteria :
 - ◆ Reduction in water absorption coefficient (A_w).
 - ◆ A compressive modulus of elasticity (E) close to that of EPS (883 kPa).





11


Water absorption coefficient analysis





OPTIMIZED COATING





12








 Laboratoire de Chimie Agro-Industrielle

Main conclusions



- Cost-effective fractionation of sunflower stalk.
- High purity of the sunflower pith fraction obtained at the end of the dry fractionation process: up to 99% (v/v).
- Thermal insulation blocks optimized:
 - ◆ Bio-based binder chosen according to its hydrophobic character.
 - ◆ Coating agents added as a water-proofing post-treatment.
 - ◆ Promising thermal and mechanical properties.
- For future work:
 - ◆ Other bio-based coating agents to be tested (e.g., waxes, drying oils like linseed oil, hydrogenated oils, etc.).
 - ◆ **Water vapour permeability measurements to be investigated.**









13





 Laboratoire de Chimie Agro-Industrielle

Pith potential for insulation materials

 Advantages		Drawbacks 
<p>1 Added value for sunflower cultivation by-products:</p> <ul style="list-style-type: none"> - Sunflower area harvested in 2022 in France: 842,000 ha [Agreste, Ministry of Agriculture] - 700 kg/ha of (stalks + heads) mechanically harvestable at the same time as sunflower seeds 		<p>1 High transport cost for the purified pith fraction</p>
<p>2 Thermal and mechanical properties in the same range as conventional insulation materials (including EPS)</p>		<p>2 Restrictive regulations for new unproven materials</p>
<p>3 For thermal resistance (R) of 3.2 m² K/W*:</p> <ul style="list-style-type: none"> - EPS → 10.5 cm - Sunflower pith block → 13.6 cm (i.e., only +29%) 		<p>* Requirement from RT2020 regulation standard in France.</p>
<p>4 Alternative to petroleum-based products</p>		
<p>5 Naturally breathable material</p>		





14



LCA
LABORATOIRE DE CHIMIE
AGRO-INDUSTRIELLE

fm
AGROMAT
R&D à l'échelle industrielle

ICBBM
Fifth International
Conference on Bio-
Based Building
Materials (3BM)
June 21-23rd 2023
Wien, Austria



TU
wien



Philippe.Evon@toulouse-inp.fr
https://www.researchgate.net/profile/Philippe_Evon

**Thank you very much
for your attention**

TOULOUSE INP Ensiacet INRAE

