



HAL
open science

Optimized vegetal wools for indoor comfort: coupling fire treatment with acoustic and hygrothermal performances

Thomas Schatzmayr Welp Sá, Sandrine Marceau, Clément Piégay, Philippe Glé, Fouad Laoutid, Cesar Segovia, Etienne Gourlay, Emmanuel Gourdon

► To cite this version:

Thomas Schatzmayr Welp Sá, Sandrine Marceau, Clément Piégay, Philippe Glé, Fouad Laoutid, et al.. Optimized vegetal wools for indoor comfort: coupling fire treatment with acoustic and hygrothermal performances. RILEM Conference on Sustainable Materials & Structures: Meeting the major challenges of the 21st century - SMS 2024, Aug 2024, Toulouse, France. hal-04682573

HAL Id: hal-04682573

<https://hal.science/hal-04682573>

Submitted on 30 Aug 2024

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.

Copyright

OPTIMIZED VEGETAL WOOLS FOR INDOOR COMFORT: COUPLING FIRE TREATMENT WITH ACOUSTIC AND HYGROTHERMAL PERFORMANCES

Thomas Schatzmayr Welp Sá ^(1,2), Sandrine Marceau ⁽¹⁾, Clément Piégay ⁽²⁾, Philippe Glé ⁽²⁾, Fouad Laoutid ⁽³⁾, Cesar Segovia ⁽⁴⁾, Etienne Gourlay ⁽⁵⁾, Emmanuel Gourdon ⁽⁶⁾

(1) Univ Eiffel, MAST-CPDM, F-77454 Marne-la-Vallée, France

(2) Cerema, Univ Eiffel, UMRAE, Agence de Strasbourg - 11 Rue Jean Mentelin, 67035 Strasbourg, France

(3) Laboratory of Polymeric & Composite Materials, Materia Nova Research Center, University of Mons (UMONS) - Mons, Belgium

(4) Cetelor - 27 Rue Philippe Seguin, 88000 Epinal, France

(5) Cerema, Equipe-projet BPE - 11 Rue Jean Mentelin, 67035 Strasbourg, France

(6) LTDS UMR CNRS 5513 (site de l'ENTPE), Labex CeLyA, 3 Rue Maurice Audin, 69120 Vaulx-en-Velin, France

Abstract ID Number (will be given by the scientific editors/organizers): **SMS-XXX**.

Keywords: sustainable building materials, vegetal wools, fireproof treatment, acoustics, hygrothermics

Author contacts

Authors	E-Mail	Postal address
Thomas Schatzmayr Welp Sá	thomas.schatzmayr-welp-sa@univ-eiffel.fr	Univ Eiffel, MAST-CPDM - F-77454 Marne-la-Vallée, France
Sandrine Marceau	sandrine.marceau@univ-eiffel.fr	Univ Eiffel, MAST-CPDM - F-77454 Marne-la-Vallée, France
Clément Piégay	clement.piegay@cerema.fr	Cerema, Univ Eiffel, UMRAE, Agence de Strasbourg - 11 Rue Jean Mentelin, 67035 Strasbourg, France
Philippe Glé	philippe.gle@cerema.fr	Cerema, Univ Eiffel, UMRAE, Agence de Strasbourg - 11 Rue Jean Mentelin, 67035 Strasbourg, France
Fouad Laoutid	fouad.laoutid@materianova.be	Laboratory of Polymeric & Composite Materials, Materia Nova Research Center, University of Mons (UMONS) - Mons, Belgium
Cesar Segovia	cesar.segovia@univ-lorraine.fr	Cetelor - 27 Rue Philippe Seguin, 88000 Epinal, France
Etienne Gourlay	etienne.gourlay@cerema.fr	Cerema, Equipe-projet BPE - 11 Rue Jean Mentelin, 67035 Strasbourg, France
Emmanuel Gourdon	emmanuel.gourdon@entpe.fr	6 LTDS UMR CNRS 5513 (site de l'ENTPE), Labex CeLyA - 3 Rue Maurice Audin, 69120 Vaulx-en-Velin, France

Contact person for the paper: Thomas Schatzmayr Welp Sá

OPTIMIZED VEGETAL WOOLS FOR INDOOR COMFORT: COUPLING FIRE TREATMENT WITH ACOUSTIC AND HYGROTHERMAL PERFORMANCES

Thomas Schatzmayr Welp Sá ^(1,2), Sandrine Marceau ⁽¹⁾, Clément Piégay ⁽²⁾, Philippe Glé ⁽²⁾, Fouad Laoutid ⁽³⁾, Cesar Segovia ⁽⁴⁾, Etienne Gourlay ⁽⁵⁾, Emmanuel Gourdon ⁽⁶⁾

(1) Univ Eiffel, MAST-CPDM, F-77454 Marne-la-Vallée, France

(2) Cerema, Univ Eiffel, UMRAE, Agence de Strasbourg - 11 Rue Jean Mentelin, 67035 Strasbourg, France

(3) Laboratory of Polymeric & Composite Materials, Materia Nova Research Center, University of Mons (UMONS) - Mons, Belgium

(4) Cetelor - 27 Rue Philippe Seguin, 88000 Epinal, France

(5) Cerema, Equipe-projet BPE - 11 Rue Jean Mentelin, 67035 Strasbourg, France

(6) LTDS UMR CNRS 5513 (site de l'ENTPE), Labex CeLyA, 3 Rue Maurice Audin, 69120 Vaulx-en-Velin, France

EXTENDED ABSTRACT

Vegetal wools are interesting materials to be used as insulator, as they provide high acoustic and hygrothermal performances [1]–[3]. Moreover, they are bio-based materials and store carbon to contribute to a sustainable development of the construction industry. However, one major concern arises regarding the material's fire resistance, especially for this application, as bio-based materials are usually flammable [4]. Therefore, to expand the applications of vegetal wools for green building insulation a fireproof treatment for this material should be considered. This work aims to investigate different methods of treatment and their impact on the acoustic and thermal performance of vegetal wools.

In this study, hemp fibres (a base material for vegetal wool), were fireproof treated with phytic acid, a bio-based source of phosphorus which can be used to improve the fire resistance of natural fibres, and urea, with two different methods: impregnation, where the fibres are immersed in solution, and pulverization, where the solution is sprayed over the fibres. Subsequently to the application of the solution, the fibres are taken to an oven for 2h, in order to graft the phosphorus on the fibres. In this step, two conditions were tested: mild (treatment at 80°C) and intermediate (treatment at 120°C). Thermal properties of reference and treated fibres were evaluated by thermogravimetric analysis (TGA) and their acoustic performance was measured by the impedance tube test.

The mass loss and its respective derivative (DTG) results are presented in Figure 1a. The reference fibres (in black) show a small mass loss until 100°C, which is related to the loss of humidity, then at around 230°C, the degradation of hemicellulose starts, followed by the thermal degradation of the cellulose, which lasts until 380°C and represents the biggest mass loss of the test [4]. Afterwards, a third mass loss is observed, which is a further degradation of the products of the combustion, known as humins [5]. This step occurs between 380°C and 520°C in the reference fibres.

In comparison with the reference, it is possible to see an earlier thermal degradation for the treated fibres. The DTG peak for the reference is at 334°C, whereas for the treated fibres, it varies from 261 to 300°C. Then, the reference fibres continue to degrade between 420°C and 520°C, and at 800°C, the residue is small (3.5%). For treated fibres, at 500°C, the mass left varies from 25.3% to 36.2%. This result is associated with the formation of a char layer over the fibres. It protects and delays the

degradation of the fibres. The earlier thermal degradation and a higher amount of residue indicates a greater amount of phosphorus grafted, and consequently, a lower flammability [6].

The Figure 1b presents the sound absorption of hemp fibres samples as a function of the frequency obtained by the impedance tube test. At low frequencies, especially lower than 300 Hz, the fibres do not perform well, in terms of sound absorption, with a α value of 0.40 for the reference fibres. From 600 Hz and onwards, the reference presented a sound absorption higher than 0.80. Overall, the results shown that the reference had a better performance, followed by IMP-MILD, IMP-INT, PUL-INT and PUL-MILD, indicating that the treatment decreased the acoustic performance. At 750 Hz, for example, the reference fibres presented a α value of 0.85, whereas the PUL-MILD fibres presented a α value of 0.69.

Further investigations will be made to evaluate the impact of the treatment on the microstructure of the fibres, which could explain the decrease in acoustic performance, and to characterize the material reaction to fire. Also, the hygrothermal performance will be evaluated as a function of the treatment. Then, the object of study will be switched from fibres to vegetal wools.

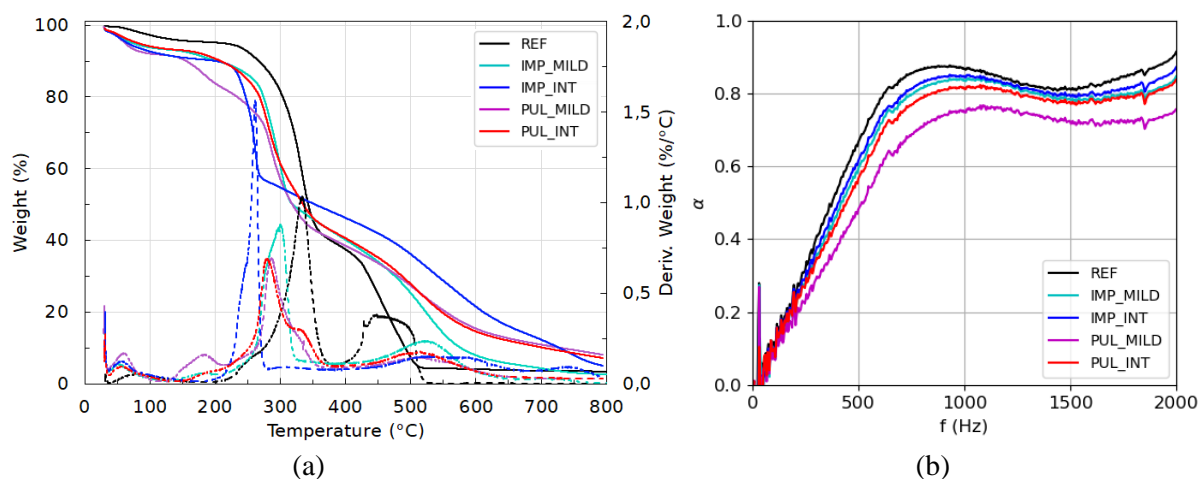


Figure 1: (a) TGA (solid line) and DTG (dashed line) of treated and non-treated hemp fibres; (b) Sound absorption of treated and non-treated hemp fibres.

Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie COFUND grant agreement N° 101034248.

REFERENCES

- [1] Collet F., Achchaq F., Djellab K., Marmoret L. and Beji H., 'Water vapor properties of two hemp wools manufactured with different treatments', *Construction and Building Materials* 25 (2) (2011) 1079–1085
- [2] Piégay C., Glé P., Gourdon E. and Gourlay E., 'A cylindrical self-consistent modelling of vegetal wools thermal conductivity', *Construction and Building Materials* 232 (2020) 117123
- [3] Piégay C., Glé P., Gourlay E., Gourdon E. and Marceau S., 'A self-consistent approach for the acoustical modeling of vegetal wools', *Journal of Sound and Vibration* 495 (2021) 115911
- [4] Dorez G., Ferry L., Sonnier R., Taguet A. and Lopez-Cuesta J.-M., 'Effect of cellulose, hemicellulose and lignin contents on pyrolysis and combustion of natural fibers', *Journal of Analytical and Applied Pyrolysis* 107 (2014) 323–331
- [5] Bausch F., Owusu D. D., Jusner P., Rosado M. J., Rencoret J., Rosner S., Río J. C., Rosenau T., Potthast A., 'Lignin Quantification of Papyri by TGA—Not a Good Idea', *Molecules* 26 (14) 4384

- [6] Antoun K., Ayadi M., El Hage, R., Nakhil M., Sonnier R., Gardiennet C., Le Moigne N., Besserer A., Brosse N., 'Renewable phosphorous-based flame retardant for lignocellulosic fibers', *Industrial Crops and Products* 186 (2022) 115265