

Natural Fibers Insulation Materials: Use of textile and agri-food waste in a circular economy perspective

*Original*

Natural Fibers Insulation Materials: Use of textile and agri-food waste in a circular economy perspective / Pennacchio, Roberto; Patrucco, Alessia; Savio, Lorenzo; Manni, Valentino; Bosia, Daniela. - ELETTRONICO. - (2021), pp. 6-8. (Intervento presentato al convegno ICNF 2021 - 5th International Conference on Natural Fibers tenutosi a Portugal nel 17-19 Maggio 2021).

*Availability:*

This version is available at: 11583/2933414 since: 2021-10-20T19:41:24Z

*Publisher:*

R. Figueiro / SCIENCENTRIS

*Published*

DOI:

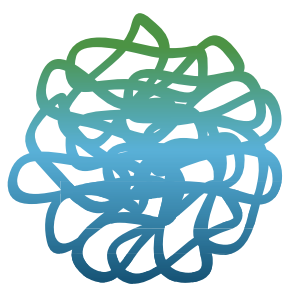
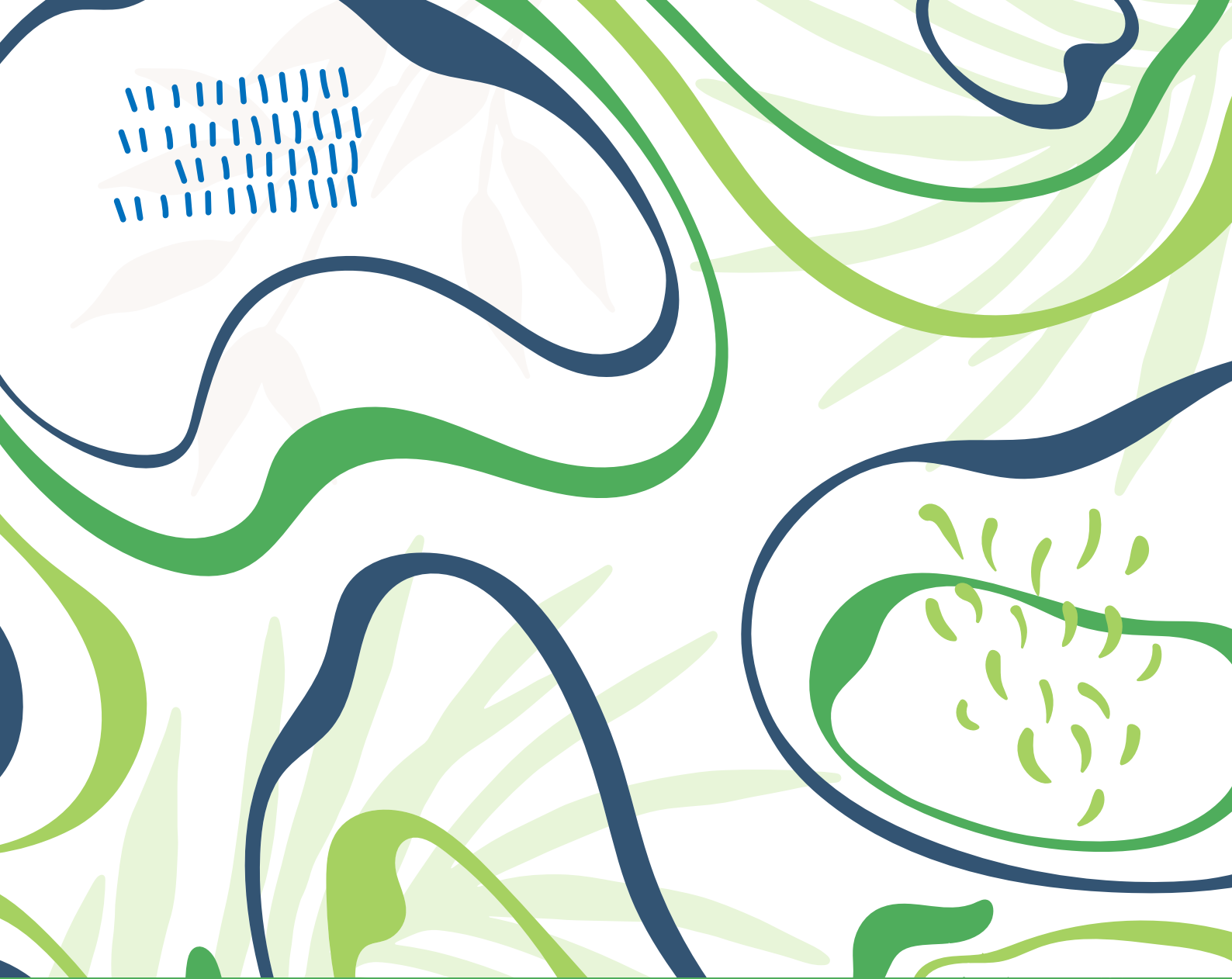
*Terms of use:*

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

*Publisher copyright*

GENERICO -- per es. Nature : semplice rinvio dal preprint/submitted, o postprint/AAM [ex default]

(Article begins on next page)



**ICNF 2021**  
5th International  
Conference on Natural Fibers

**Materials of the Future**

17. 18. 19 MAY 2021 | Online, Portugal

# Book of Abstracts

Edited by R. Figueiro



**ICNF 2021**  
5th International  
Conference on Natural Fibers  
**Materials of the Future**



# BOOK OF ABSTRACTS

Edited by

**RAUL FANGUEIRO**

Cover

**PIXARTIDEA**

Publisher

**SCIENCENTRIS**

Representation in whole or in part by any means is not permitted without consent of the editors

Authors

Multiple

Title

Proceedings of the 5th International Conference on Natural Fibers - Materials of the Future

ISBN

978-989-54808-5-2

The editor is not responsible for any author's errors in spelling, grammar or scientific facts. The content of Abstracts is the sole responsibility of the authors.

© Copyright: Local Organizing Committee, 2021

17 . 18 . 19  
MAY 2021  
Online, Portugal

ORGANIZED BY



# FOREWORD

The International Conference on Natural Fibers is established as the leading scientific event on fields related to natural fibers, from harvesting to its application in high demanding areas. Over the last 4 editions, this event has assumed a very important worldwide position, addressing and defining the most important trends in the field, as an outcome of the high quality of the research works presented and of the strong interaction among the participants.

With a very transversal view on the extraction, processing, functionalization and use of natural fibers, including linen, wool, silk, hemp and cotton, ICNF2021 focuses, in this edition, on the topic “Materials of the Future”, clearly assuming the fundamental role of these materials in building a more sustainable future. In fact, areas such as automobiles, aeronautics, fashion, civil construction, architecture or health-care, have been benefiting strongly from the scientific advances occurred in the last decades in this field, focused mainly on the combination of intrinsic characteristics associated with sustainability and the performance provided by these materials. Biocomposites for use in automobile and aircraft components, geotextiles for use in soil reinforcement, nanocellulose for use in medical devices and fibers for reinforcing construction mortars, are just some examples of fundamental themes for the use of advanced natural fibers. In this context, nanotechnology is also of particular importance in the search for the most appropriate solutions for specific applications, in a logic of multiscale analysis of materials, with a view to their manipulation at the nano, micro and macro scales. Over the last few years, intensive research has been developed to turn natural fibers into smart solutions being able to respond to external stimuli, in addition to their intrinsic sustainable features.

ICNF2021 is covering a wide range of trends defined for natural fibers, with particular emphasis on nanocellulose based fibers and structures, fiber surface treatments, functional natural fibers, smart natural fibers, environmental impact, ecomposites, biomimetics, and, of course, product development based on natural fibers.

ICNF2021 is the meeting point for all those interested in these fantastic materials called Natural Fibers.

Guimarães, 14th May 2021

**Raul Figueiro**

*Conference Chairman*



## CONFERENCE CHAIR

Raul Fanguero, School of Engineering, University of Minho, Portugal

## ORGANIZING COMMITTEE

**Carlos Mota**, Fibrenamics, University of Minho  
**Cristina Silva**, Fibrenamics, University of Minho  
**Daniel Barros**, Fibrenamics, University of Minho  
**Diana Ferreira**, Fibrenamics, University of Minho  
**Diogo Cachetas**, Fibrenamics, University of Minho  
**Edite Felgueiras**, Fibrenamics, University of Minho  
**Ehsan Omidvar**, Fibrenamics, University of Minho  
**Fernando Cunha**, Fibrenamics, University of Minho  
**Fernando Leite**, Fibrenamics, University of Minho  
**Inês Boticas**, Fibrenamics, University of Minho  
**Ivo Cruz**, Fibrenamics, University of Minho  
**Joana Araújo**, Fibrenamics, University of Minho  
**João Bessa**, Fibrenamics, University of Minho  
**José Sousa**, Fibrenamics, University of Minho  
**Luís Nobre**, Fibrenamics, University of Minho  
**Miguel Costa**, Fibrenamics, University of Minho  
**Mohammadmahdi Abedi**, Fibrenamics, University of Minho  
**Pedro Silva**, Fibrenamics, University of Minho  
**Raquel Galante**, Fibrenamics, University of Minho  
**Ricardo Zocca**, Fibrenamics, University of Minho  
**Rita Costa**, Fibrenamics, University of Minho  
**Sara Silva**, Fibrenamics, University of Minho  
**Sílvia Ferreira**, Fibrenamics, University of Minho  
**Sofia Costa**, Fibrenamics, University of Minho  
**Sofia Tavares**, Fibrenamics, University of Minho  
**Usha Sanivada**, Fibrenamics, University of Minho  
**Vânia Pais**, Fibrenamics, University of Minho

## SCIENTIFIC COMMITTEE

**Adriana Restrepo**, Universidad Pontificia Bolivariana, Colombia

**Aart Van Vuure**, Katholic University of Leuven, Belgium

**Alain Bourmaud**, Université Bretagne Sud, France

**Alain Dufresne**, Grenoble Institute of Technology, France

**Aloysio Gomes**, Universidade Federal Tecnológica do Paraná, Brazil

**António Torres Marques**, University of Porto, Portugal

**Carlos Orrego Alzate**, National University of Colombia, Colombia

**Carmen Freire**, University of Aveiro, Portugal

**Claudio Scarponi**, Sapienza University of Rome, Italy

**Diana Ferreira**, University of Minho, Portugal

**Fabrizio Sarasini**, Sapienza University of Rome, Italy

**Gary Chinga Carrasco**, Paper and Fibre Research Institute, Norway

**Helena Vasconcelos**, University of the Azores, Portugal

**Hitoshi Takagi**, Tokushima University, Japan

**Holmer Savastano**, University of S. Paulo, Brazil

**Hong Hu**, Hong Kong Polytechnic University, China

**John Summerscales**, Plymouth University, United Kingdom

**Jörg Müssig**, Bremen University of Applied Sciences, Germany

**Juan Hinestroza**, Cornell University, United States of America

**Júlia Baruque Ramos**, University of São Paulo, Brazil

**Kim Pickering**, The University of Waikato, New Zealand

**Lars Berglund**, KTH Royal Institute of Technology, Sweden

**Lubos Hes**, Technical University of Liberec, Czech Republic

**Malgorzata Zimniewska**, Institute of Natural Fibers and Medicinal Plants, Poland

**Maya John**, CSIR, South Africa

**María Paz Sáez**, University of Granada, Spain

**Mark P. Staiger**, University of Canterbury, New Zealand

**Mário de Araújo**, University of Minho, Portugal

**Miguel Chavez Gutierrez**, Instituto Politecnico Nacional, México

**Mirela Blaga**, Technical University of Iasi, Romania

**Mohammad Jawaid**, University Putra Malaysia, Malaysia

**Mohd Sapuan Salit**, Universiti Putra Malaysia, Malaysia

**Morsyleide Rosa**, Embrapa, Brazil

**Nolene Byrne**, Deakin University, Australia

**Orlando Rojas**, Aalto University, Finland

**Patrícia Marino**, National Institute for Industrial Technology, Argentina

**Paulo Lourenço**, University of Minho, Portugal

**Pierre Ouagne**, National College of Engineering of Tarbes, France

**Rachel Laing**, University of Otago, New Zealand

**Raj Das**, University of Auckland, New Zealand

**Rajesh Anandjiwala**, Nelson Mandela University, South Africa

**Ramaswamy Nagarajan**, University of Massachusetts Lowell, USA

**Ryszard Michal Kozłowski**, Institute of Natural Fibres & Medicinal Plants, Poland

**Sabu Thomas**, Mahatma Gandhi University, India

**Seeram Ramakrishna**, National University of Singapore, Singapore

**Sofianne Amziane**, Polytech' Clermont, France

**Sohel Rana**, Fibrenamics, University of Minho, Portugal

**Steve Eichhorn**, University of Bristol, United Kingdom

**Xiangming Zhou**, Brunel University London, United Kingdom

**Xungai Wang**, Deakin University, Australia

**You-Lo Hsieh**, University of California, USA

# NATURAL FIBERS INSULATION MATERIALS: USE OF TEXTILE AND AGRI-FOOD WASTE IN A CIRCULAR ECONOMY PERSPECTIVE

Roberto Pennacchio<sup>1(\*)</sup>, Alessia Patrucco<sup>2</sup>, Lorenzo Savio<sup>3</sup>, Valentino Manni<sup>4</sup>, Daniela Bosia<sup>5</sup>

<sup>1,3,4,5</sup> DAD, Department of Architecture and Design, Politecnico di Torino, Italy

<sup>2</sup> STIIMA-BI ISMAC, CNR, Biella, Italy

(\*) Email: roberto.pennacchio@polito.it

## ABSTRACT

Fibrous-based materials are among the most used for the thermal and acoustic insulation of building envelopes and among the ones with the best flexibility in use. In building construction, the demand for products with low environmental impact - in line with the Green Deal challenge of the European Community - is growing, but the building market is still mostly biased towards traditional products, missing the many opportunities for using waste materials from existing industrial production. The paper presents the experimental results of new thermal and acoustic insulation products for building construction and interior design, based on previous experiences of the research group. They are entirely produced using waste sheep's wool as a "matrix" and other waste fibers, as "fillers". Proposed materials derive from textile and agro-industrial chains of Piedmont region and have no other uses, different from the thermal valorization as biomass. The panels have characteristics of rigidity, workability, and thermal conductivity that make them suitable for building envelope insulation.

## INTRODUCTION

In 2017 in Italian building regulations have been introduced the CAMs (Minimum Environmental Criteria), which are environmental requirements defined for the various phases of the purchasing process, aimed at identifying the best design solution, product, or service from an environmental point of view, along the life cycle. The consequent growing demand for low-environmental-impact building products often does not match adequate availability in the building market. Fibrous-based thermal and acoustic insulation panels are a clear example of building products that could be produced using almost exclusively by-products from already existing industrial production chains, meeting the CAM requirements.

The paper presents innovative solutions in the use of natural fibers for the production of insulating panels, exploring the use of waste materials available in the agri-food and textile production chains. The AGROTESs panels production concept aims to close existing production cycles in a regional industrial system (Piedmont Region, Italy), avoiding the disposal of fibrous waste and reintroducing them into a new production cycle, in a circular economy perspective. AGROTESs panels combine wasted sheep's wool from regional sheep farming and other waste materials like rice straw, chopped corn, fibrous wastes from textile productions.

Proposed rigid panels consist of a keratin "matrix" and a fibrous "filler". Their production process come from research works, previously carried on at DAD of Politecnico di Torino and CNR-ISMAC of Biella (Piedmont) (Pennacchio et al. 2017), and use keratin in wool fibers as a binder, through a thermochemical fusion in a caustic soda bath, keeping unaltered the main chemical and physical characteristics of employed materials. Further research development recently led to test new waste materials, coming from Piedmont region agri-food production chains, to be used as a filler, as an alternative to hemp, adapting the production process - materials percentage, concentration of soda solution, drying process - according to the specific features of





new selected materials, which also give the panels different density and rigidity characteristics. Among the various local “fillers” experimented during laboratory tests, rice straw fibers and chopped corn showed better compatibility with wool fibers, and their use have been further investigated. At the same time, a different panels’ production process have been developed, using powders from wool textile chains, with high keratin content, with no need of mixing with coarse wool fibers.

Research mainly focused on Piedmont region, but could be extended and adapted to other areas with high availability of coarse wool.

Test and measurements have been provided on experimental samples in order to identify opportunities for the production of new low environmental impact products, suitable for the building sector and meeting the CAM requirements and European Green Deal challenge for nearly zero-emission productions.

## RESULTS AND CONCLUSIONS

The paper presents, as a result of the experiments on different natural fibers and waste materials, the production process for the production of the insulating panels’ samples. In the process, the keratin in wool fibers acts as “matrix” which glues the different “fillers” in treatment with caustic soda. Quantity of components, times, and phases of the production process has been tested and optimized to obtain the densities and physical-technical performances necessary for the use of the panels as well-performant insulations for in construction.

Unidirectional steady-state thermal performance measures (tab.1) obtained through laboratory tests carried out using the guarded ring hot plate method (ISO 8302:1991; UNI EN 12667:2002) show thermal conductivity values slightly higher if compared with those found in previous experimental panels and those of natural insulation products on currently the market (Pennacchio et al. 2017).

Table 1 AGROTESs samples measured thermal characteristics

	<b>Dim</b> <b>[cm]</b>	<b>Mass</b> <b>[g]</b>	<b>Bulk Density</b> <b>[kg/m<sup>3</sup>]</b>	<b>λ</b> <b>[W/mK]</b>	<b>R</b> <b>[m<sup>2</sup>K/w]</b>	<b>U</b> <b>[W/m<sup>2</sup>K]</b>
<b>AGROTESs A</b>	15x15x3.5	161	204	0.054	0.648	1.543
<b>AGROTESs B</b>	15x14x3.5	141	249	0.063	0.429	2.331
<b>AGROTESs C</b>	15x15x2.2	134	203	-	-	-
<b>AGROTESs C<sub>1</sub></b>	14.5x13.5x2.2	136	240	0.061	0.475	2.105

Nevertheless, their high bulk density would make interesting the evaluation of panels’ dynamic thermal behaviour. Results obtained, however, eventually open to the possibility of further improving the thermal conductivity performance, through calibrated pressing systems during panels’ production.

AGROTESs insulating panels are suitable for multiple uses in architectural field, both in new construction and rehabilitation processes, as for building envelope insulation, as for internal partitions, offering good workability and adaptation to traditional anchoring systems (Savio et al. 2018).

## ACKNOWLEDGMENTS

The authors gratefully acknowledge Agrindustria Tecco s.r.l. (Cuneo, Italy) for the waste materials supply used in the samples production.

## REFERENCES

- [1] Pennacchio R, Savio L, Bosia D, Thiebat F, Piccablotto G, Patrucco A, Fantucci S. Fitness: Sheep-wool and hemp sustainable insulation panels. Energy Procedia, Elsevier, 2017, 111, p. 287-297.
- [2] Savio L, Bosia D, Patrucco A, Pennacchio R, Piccablotto G, Thiebat F. Applications of building insulation products based on natural wool and hemp fibers. In: Figueiro R, Rana S (ed) Advances in Natural Fibre Composites. Springer International Publishing, 2018 p. 237-247.

- [3] Tonin C, Patrucco A, Ramella Pollone F., Bosia D, Savio L, Giordano R. Processo di lavorazione della lana, materiali di lana prodotti con detto processo e articoli comprendenti detti materiali di lana. Italian Patent 0001410156. 2011 September 5th 2014GE2012A000029.
- [4] ISO 8302:1991 “Thermal insulation - Determination of steady-state thermal resistance and related properties - Guarded hot plate apparatus”.
- [5] UNI EN 12667:2002 “Prestazione termica dei materiali e dei prodotti per edilizia - Determinazione della resistenza termica con il metodo della piastra calda con anello di guardia e con il metodo del termoflussimetro - Prodotti con alta e media resistenza termica”.
- [6] UNI EN ISO 13786:2008. Thermal performance of building components—Dynamic thermal characteristics—Calculation methods.
- [7] Dissanayake DGK, Weerasinghe DU, Thebuwanage LM, Bandara UAAN. An environmentally friendly sound insulation material from post-industrial textile waste and natural rubber, *Journal of Building Engineering*, Volume 33, 2021, 101606, ISSN 2352-7102.
- [8] Wang Y. Fiber and textile waste Utilization, *Waste Biomass Valorization*, 1 (1) (2010), pp. 135-143.
- [9] Seddeq HS, Aly NM, Marwa A, Elshakankery MH. Investigation on sound absorption properties for recycled fibrous materials, *J. Ind. Textil.*, 43 (1) (2013), pp. 56-73.