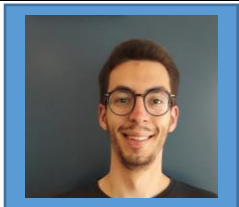


ESR 6

Project title and research strand:	Biopolymer based Aerogels: from lab to technical scale. Strand 1: Fibers for technical application.	
Name:	Diogo Manuel Amaral Santos Costa	
Supervisors, affiliation:	Barbara Milow; DLR (DE) Francisco Ruiz; KEEY (FR)	

Abstract

This work focused on the synthesis of cellulose aerogels from hemp and flax waste bast fibers for thermal insulation purposes. These aerogels were produced in different shapes and sizes. The best synthesis recipes were chosen for upscaling and were applied using the Jet-Cutter® (beads), the CAProLi (Cellulose Aerogel Production Line, for sheets/films), and wet-spinning technologies (fibers). The aerogel samples were characterized by their chemical composition, morphology, structure, and others. Pure cellulose was extracted from the bast waste fibers and the addition of sodium chloride, and sodium sulfate to the cellulose solution accelerated its gelation while improving the internal structure of the aerogel samples. A smoother cellulose gelation was achieved when weaker organic acids were used as regeneration baths. The aerogels synthesized presented high porosities (over 80%), high specific surface areas (over 200 m² g⁻¹), and low densities (< 0.21 g cm⁻³). The upscaling of the synthesis of aerogels was effective for all equipment used with little differences between different scales and sources of cellulose (hemp and commercial). The thermal conductivity of the aerogels ranged from 37 mW m⁻¹ K⁻¹ to 40 mW m⁻¹ K⁻¹, providing space for further improvement. Soda lignin was effective as a coating agent for cellulose wet gels achieving a 40% reduction in water absorption for the coated aerogels. This approach has environmental and economic advantages compared to laboratory batch-wise synthetic routes, which contribute to the development of the industrial aerogel market and a circular bio-based economy.

Bio-based Aerogels: from lab to technical scale

Diogo Costa^{1,2,3}

¹ German Aerospace Center (DLR), Institute of Materials Research, Department of Aerogels and Aerogel Composites, Linder Hoehe, 51147 Cologne, Germany
² University of Cologne (UoC), Department of Chemistry, Nanostructured Cellular Materials, Grintstraße 6, 50939 Cologne, Germany.
³ KEY Aerogels, 203 Rue du Général de Gaulle, 68440 Habsheim, France

*Diogo.Costa@dlr.de

Introduction

Background

Academia and industry are developing ways to produce novel aerogel materials from renewable bio-based sources.

Cellulose is the most abundant polysaccharide on earth, and it is known for its:

- Renewability,¹
- Low economic and environmental footprint,¹
- Chemical and thermal stability.¹

Research questions

Is it possible to efficiently extract cellulose from hemp and flax bast waste fibers?

Do the aerogels synthesized from the extracted celluloses have similar properties to those produced from commercial celluloses?

Can their production be upscaled in various shapes (beads, films, and fibers)?²

Approach

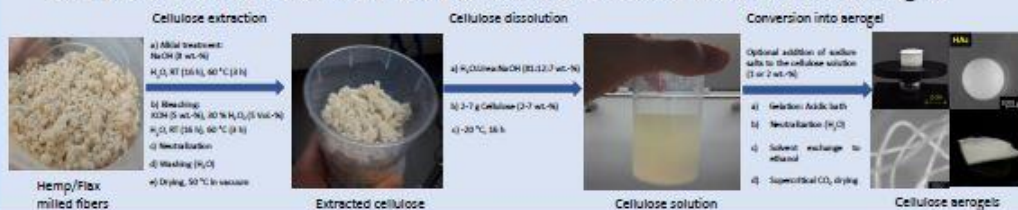
Firstly, fundamental research on cellulose dissolution and gelation conditions was performed to optimize the properties of the synthesized aerogels.

Optimized aerogel recipes were used using extracted and commercial celluloses, in different shapes and scales.

Coating of the aerogels with lignin was tested to increase their resistance to water.

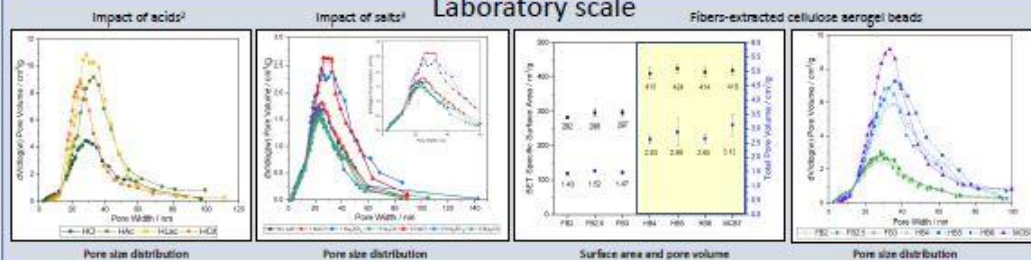
Methods

Extraction of cellulose from waste fibers and its conversion into aerogels



Discussion of results

Laboratory scale



Conclusions

Main conclusions

- The use of weak acids as coagulation baths and the addition of salts tailor the porous structure of the aerogels.
- The aerogels synthesized from hemp-extracted and commercial cellulose had similar properties in multiple shapes and scales.
- The coating of cellulose aerogels with lignin reduced their water absorption while protecting their structure.

Future prospective

- Study the influence of hemp breeding on the properties of its cellulose and resultant aerogels.
- Develop technical continuous production lines for the synthesis of aerogels in different shapes (beads, films, fibers).
- Evaluate the impact of lignin coating on the thermal conductivity of cellulose aerogels.

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- References:**
- 1 - Marais, J. P., Marais, J. P. & Rodrigues, J. Fibers, 7(11), 245, 2019.
 - 2 - Costa, D., Milow, B. & Guzman, G. (2024). Impact of weak organic acids as coagulants on tailoring the properties of cellulose aerogel beads. (Manuscript submitted for publication).
 - 3 - Manuscript in preparation.
 - 4 - Patent applied (Deutscher Patentantrag 10 2023 131 540-2).
 - 5 - Patent applied (Deutscher Patentantrag 10 2024 111 076-2).