Recyclable cellulose aerogels, a sustainable material for lightweight construction and insulation applications

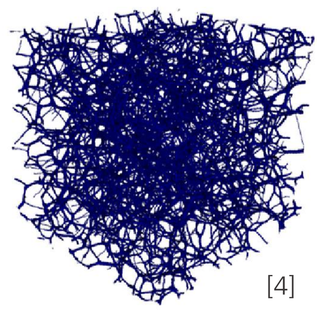
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Introduction

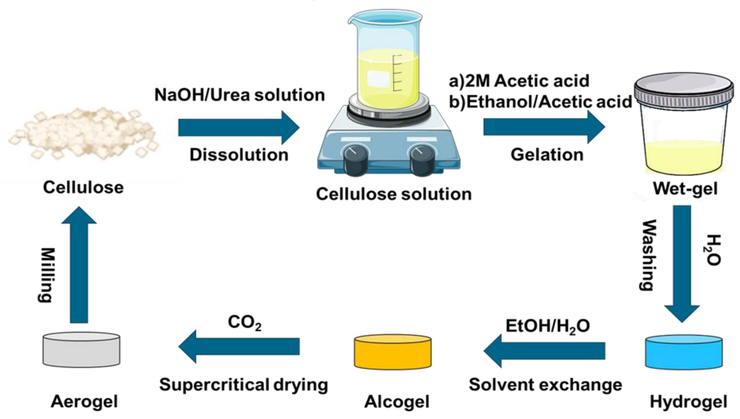
Cellulose is the most abundant biopolymer on Earth and is known by its high availability, safety and biodegradability. Therefore, cellulose's promising properties make it a sustainable material for aerogel production. Aerogels are highly porous (85%-99.8%) materials, based on gels where the liquid in the synthesized gel network is replaced with gas, while preventing pore collapse. This leads to materials with very high surface areas (up to 1200 $m^2 \cdot g^{-1}$), low densities (< 0.2 $g \cdot cm^{-3}$) and extremely low thermal conductivities (< $5 \cdot 10^{-2}$ $W \cdot (m \cdot K)^{-1}$) [1-3]. Thus, cellulose aerogels show great potential for the production of sustainable materials with exceptional physical properties. The aim of this work is to demonstrate the potential of cellulose aerogels for lightweight construction and as a base for sustainable thermal insulation. Here we show the capability of completely recycling cellulose aerogels into a new aerogel material with comparable properties as a potential end-of-life strategy as well as showing the possibility of using lignocellulosic biowaste as an alternative feedstock.



[4]

Methodology

Synthesis





Monoliths



Beads



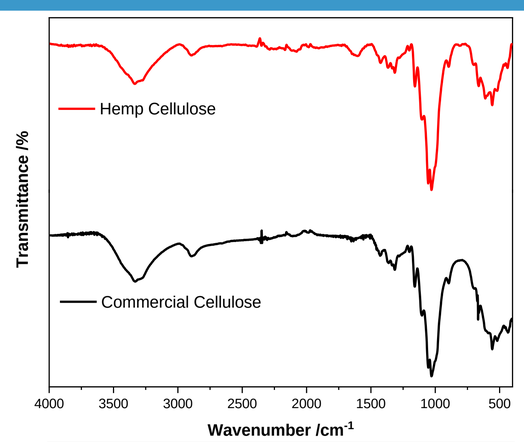
Sheets

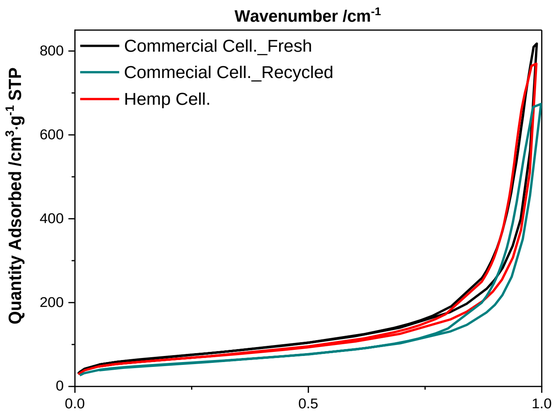
Extraction from Hemp Fibers

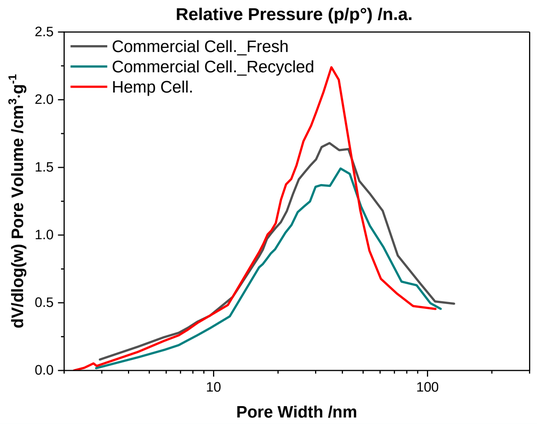


Raw Hemp Fiber | Milled Hemp Fiber | Hemp Cellulose

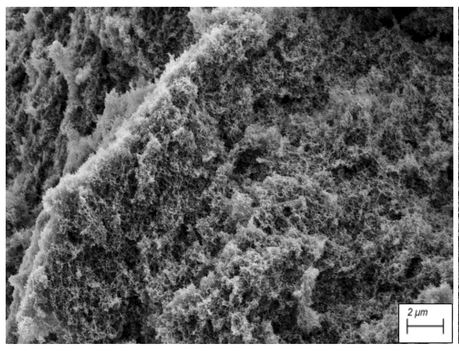
Results



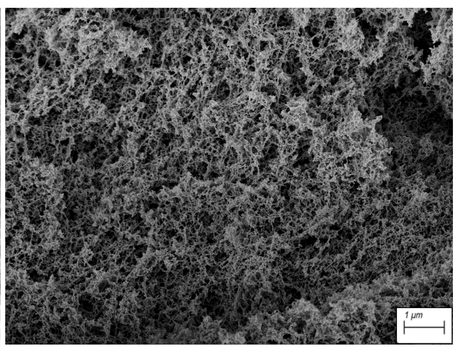




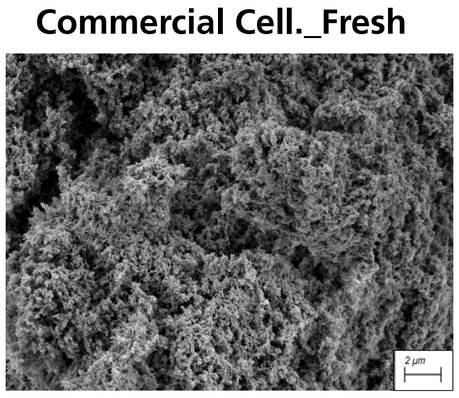
Aerogel Sample	BET Surface Area / $m^2 \cdot g^{-1}$	Average Pore Size / nm	Envelope Density / $g \cdot cm^{-3}$	Thermal Conductivity / $mW \cdot (m \cdot K)^{-1}$
Commercial Cell._Fresh	255	19.1	0.14	34
Commercial Cell._Recycled	191	20.8	0.19	34
Hemp Cell.	228	19.7	0.16	34



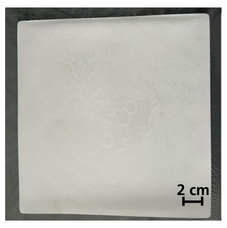
Commercial Cell._Fresh



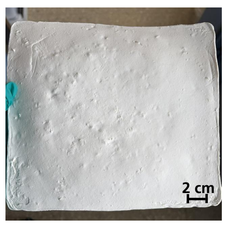
Commercial Cell._Recycled



Hemp Cell.



Commercial Cell. Aerogel



Hemp Cell. Aerogel

Summary & Conclusion

- Successful production of recycled cellulose aerogels with same synthesis route using milled cellulose aerogels as resource.
- Successful extraction of cellulose from hemp biowaste.
- Successful production of hemp based cellulose aerogels.

➢ Comparable properties of synthesized cellulose aerogels.

➢ Less resources needed for hemp cellulose aerogels.

➢ Thermal conductivity of cellulose aerogels similar to mineral wool.



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[2] Lichtfouse, E., et al., Inorganic-Organic Composites for Water and Wastewater Treatment: Volume 2. 2021: Springer.

[3] Rudaz, C., et al., Aeropectin: Fully Biomass-Based Mechanically Strong and Thermal Superinsulating Aerogel. Biomacromolecules, 2014. 15(6): p. 2188–2195.

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