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BIO-AÉROGELS :
DES MATÉRIAUX MULTI-FONCTIONNELS

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SOMMAIRE

Introduction: aerogels and bio-aerogels

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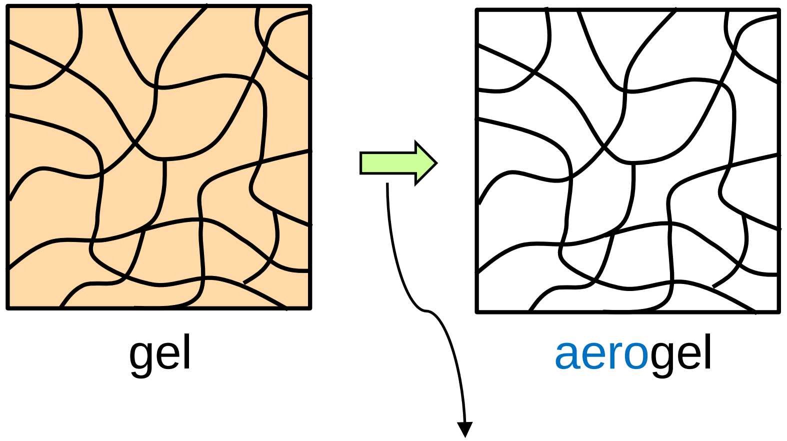
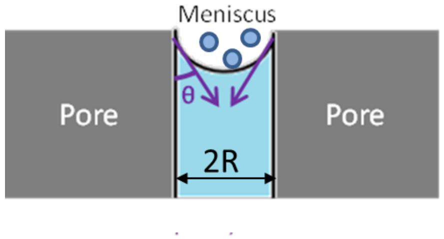


Drying with super-critical CO_2

- Solid open-pores network
- Density: 0.01 – 0.2 g/cm^3
- Nanostructured: mesoporous (2-50 nm) and small macropores (few 100 nm)
- High specific surface area: 100 - 1000 m^2/g

During drying:

$$capillary\ pressure = \frac{(surface\ tension\ liquid\ /gas) \times \cos\theta}{pore\ radius}$$



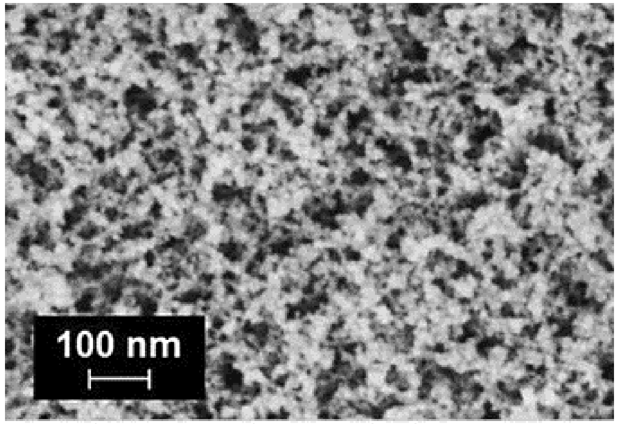
Preserving network morphology?

- Super-critical (CO_2) drying (no meniscus) ***Aero*gel** → +
- Freeze-drying (lyophilisation) ***Cryo*gel** → +/- (less than more)
- Ambient pressure or vacuum ***Xero*gel** → - (few exceptions)

Introduction: aerogels and bio-aerogels

Before the 21st century:

- Silica and metal oxide aerogels
- Synthetic polymer aerogels



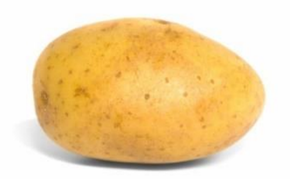
Markevicius et al, J Mater Sci (2017) 52, 2210

Applications:

- Thermal and acoustic insulation
- « Carbons » (batteries, fuel cell membranes)
- Catalyst and catalyst support
- Adsorption, absorption, purification

BIO: Cellulose, starch, marine polymers (alginate, etc) – **abundant and renewable**

cellulose



starch

alginate, carrageenan

pectin

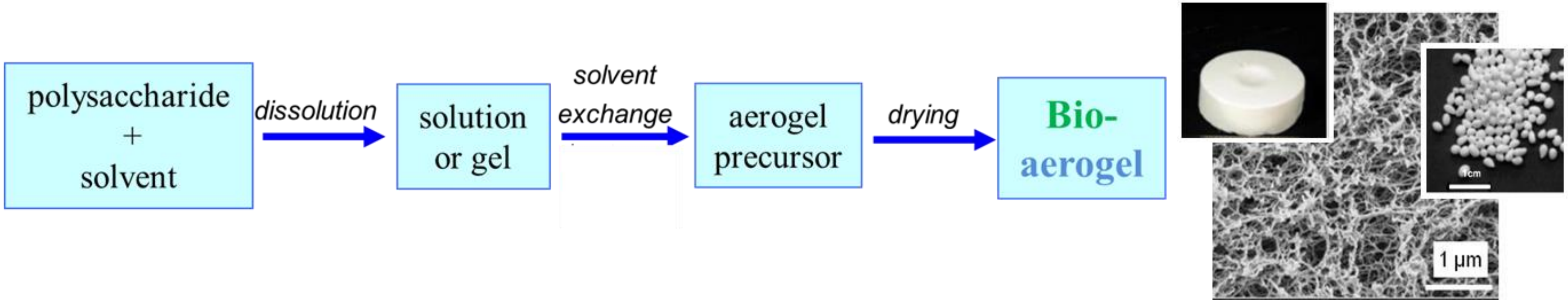
chitin, chitosan

Polysaccharides are « human-firendly »: widely used in food, feed, pharma, textile, cosmetics, etc

Bio + aerogel: can bio-aerogel do the same or better? New applications for « old » polymers?

Introduction: aerogels and bio-aerogels

Bio-aerogels are made from polysaccharides without any toxic compound :



Examples of properties and potential applications:

- Thermal (super)insulation
- Electro-chemical
- For controlled release

Three examples of bio-aerogels

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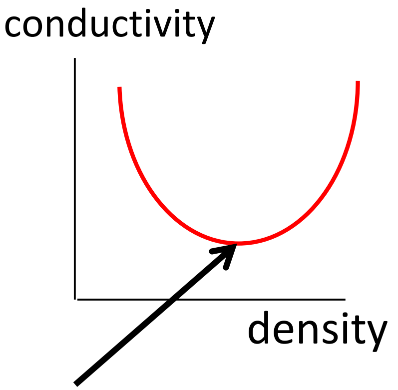
Three examples of bio-aerogels: thermal insulation

For porous materials: thermal conductivity $\lambda = \lambda$ (solid) + λ (gas) + λ (radiation)

low density needed

$\lambda_{gas} < \lambda_{gas\ ambient\ air}$ ***(Knudsen effect)***

pore size < free mean path of (air) molecule (~ 70 nm)



A compromise is needed between the density and pore size to get the lowest thermal conductivity

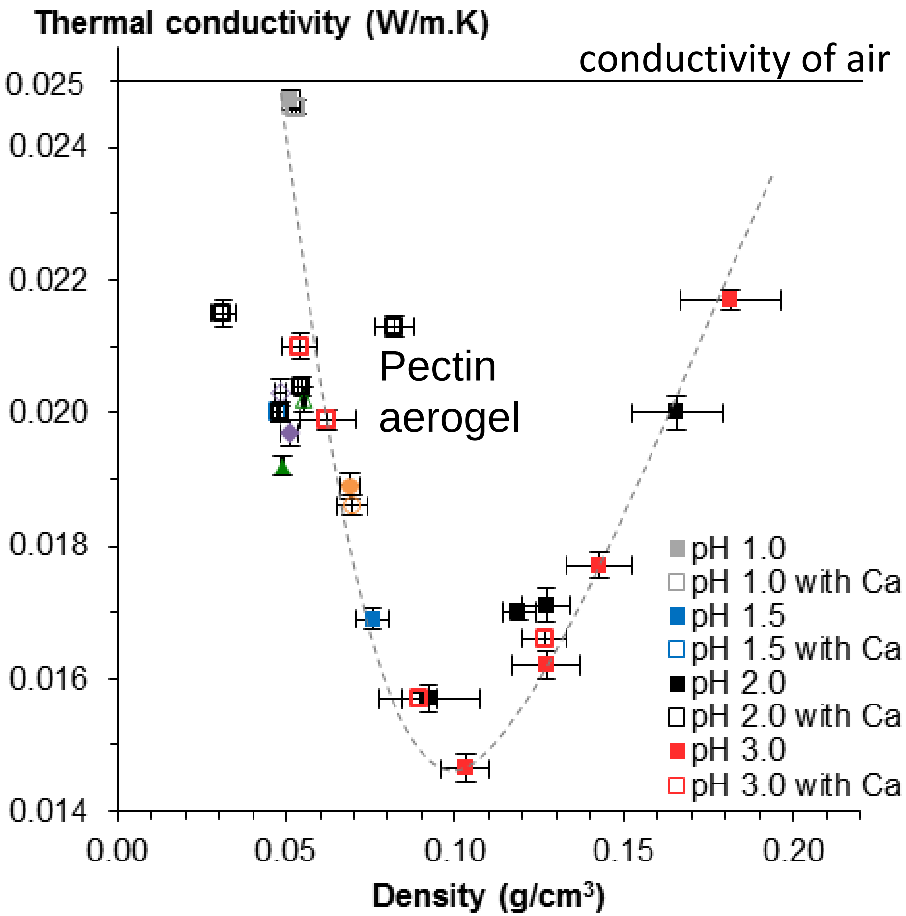
<u>SiO_2 aerogel:</u>

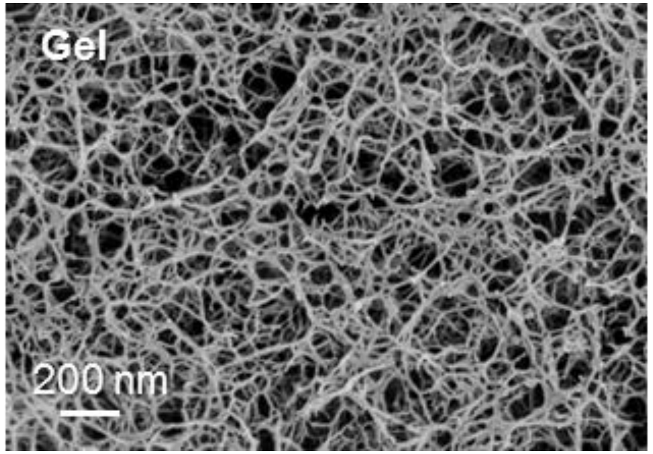
Pore size ~10-70 nm

ρ ~ 0.1 g/cm^3

λ ~ **0.013** W.m^{-1}.K^{-1}

Air: 0.025 W.m^{-1}.K^{-1}





Groult et al (2018) Carbohydr Polym 196:73

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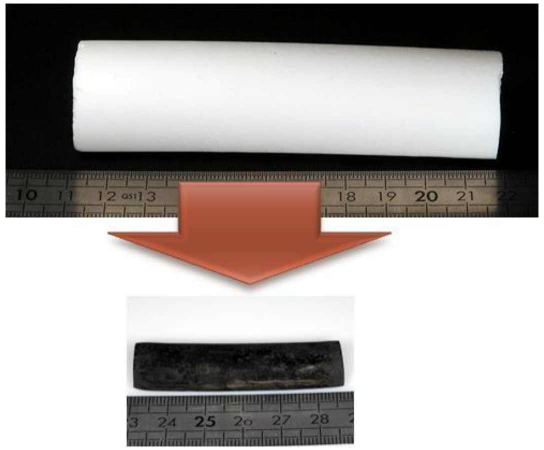
Three examples of bio-aerogels: electro-chemical

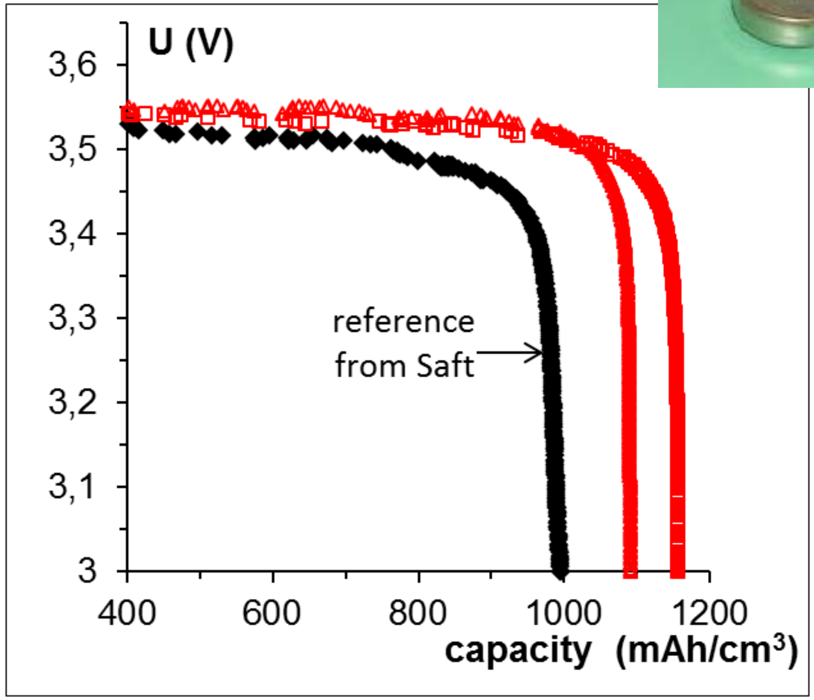
Nanostructured « green » monolithic carbon

Made by pyrolysis of cellulose aerogel:



- Density : 0.2-0.3 g/cm^3
- Mesoporous volume: 2 – 4 cm^3 g^{-1}
- Average macropores diameter: 80 - 90 nm
- Specific surface BET : 200-300 m²/g
- Average micropores diameter : 2.4-6 nm

Discharge experiments



- High shrinkage, but **<u>monolithic material</u>**
- **Tunable shape**
- Excellent results for lithium cells: **volume capacity increased by 10-15 %**

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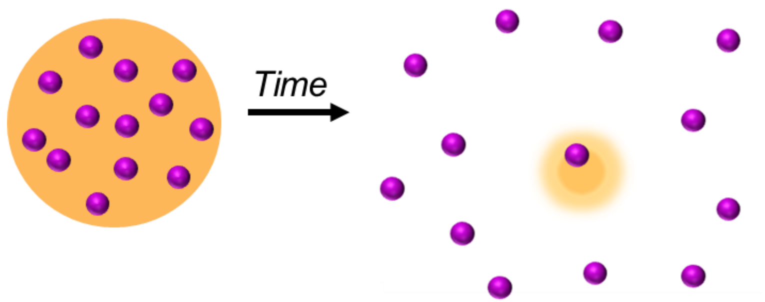
Three examples of bio-aerogels: controlled release

As a delivery matrix of active compounds:

- Pharma
- Cosmetics
- Food
- Agriculture

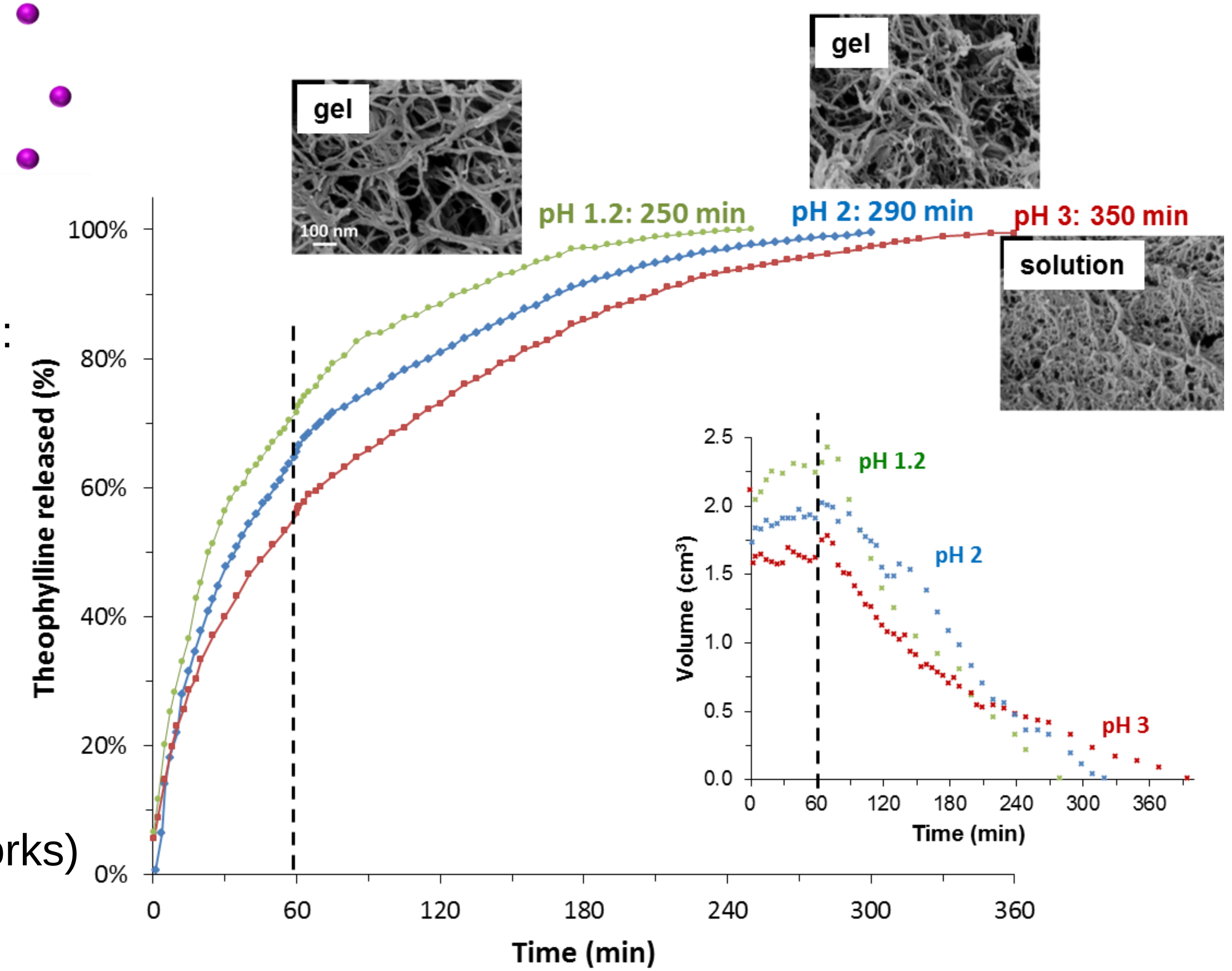


Kinetics of release can be tuned by aerogel properties:

- Density
- Specific surface
- Aerogel matrix swelling/solubility

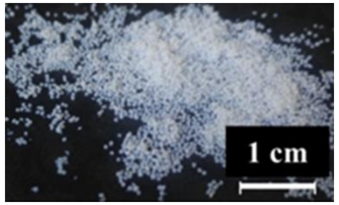
Advantage as compared to hydrogels:

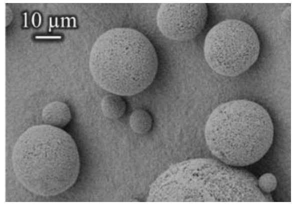
- Lightweight
- Shape stability (dry)
- No contamination
- Large variety of formulations (interpenetrated networks)



Conclusions and prospects

- New bio-based materials were created: bio-aerogels
- Low density (around 0.1 g/cm^3), high internal pores area (100 – 700 g/cm^3), versatile
- Possible to make organic-organic and organic-inorganic aerogels: increases the versatility of bio-aerogels and enormously varies the properties
- Possible to make aerogels of « any » shape: from monoliths to beads of few mm to few µm
- Applications: as carriers, insulation, carbons – life science, engineering, energy





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Merci!

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