Remediation of Microplastics Using Polymer Nanofibers

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Microplastic (MP) Pollution

- **The average person consumes 11,845 and 193,200 microplastic (MP) particles per year**

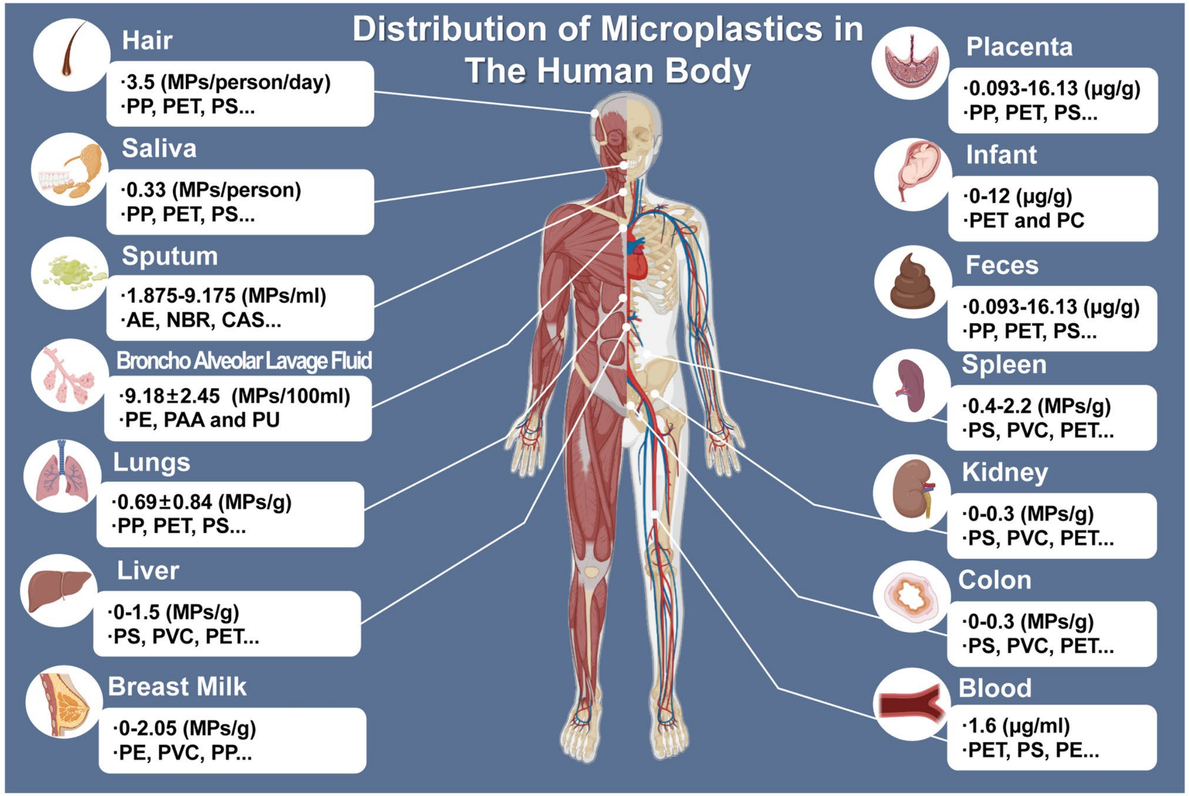
(Hoang et al., *Frontiers in Environmental Science*, June 2025)

- **Drinking water is the primary route of MP exposure**

(Hoang et al., *Frontiers in Environmental Science*, June 2025)

- **Current methods of removal in water treatment often struggle with smaller particles (<50μm)**

(Shahariar et al., *Journal of Water Process Engineering*, May 2026)



(Yang et al., *Current Pollution Reports*, August 2023)

Current Remediation Methods

Flocculation/Sedimentation

- Use of chemical agents to clump and sediment small particles.
- <0.1% removal of 1μm MP particles.

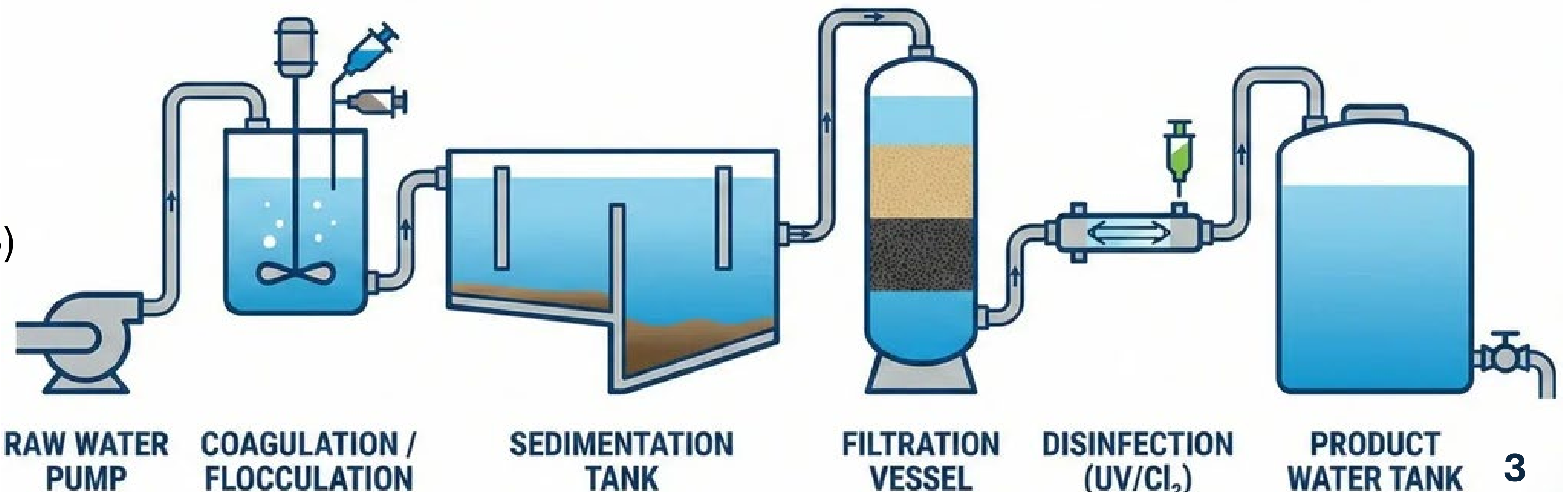
(Shahariar et al., *Journal of Water Process Engineering*, May 2026)

Granular Filtration

- Uses sand or activated carbon in large **(~50cm tall**) filter columns
- Completely removes microplastics >100μm
- Microplastics <50μm have worse removal efficiency (85-95%)

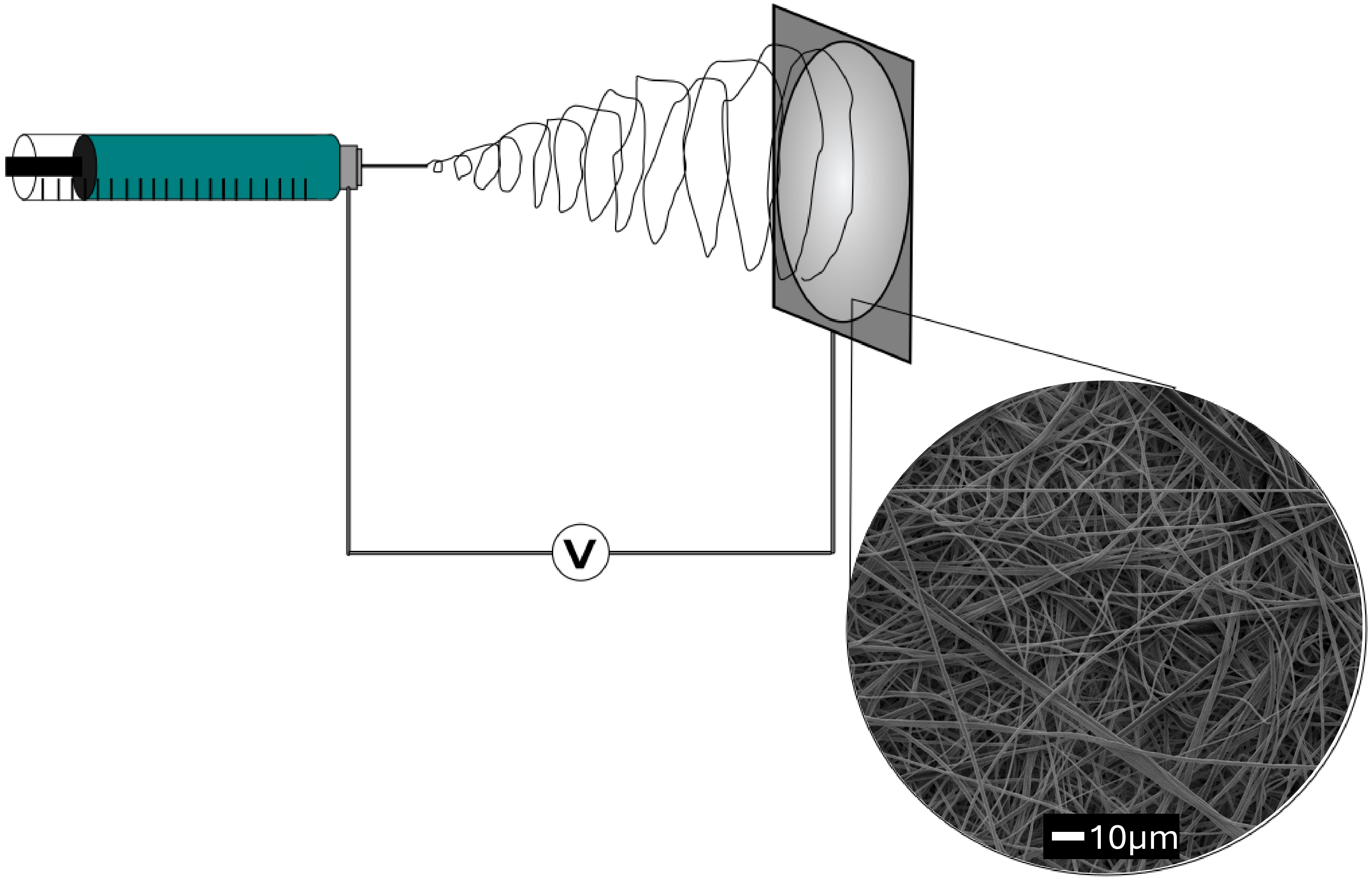
(Zhang et al., *Science of The Total Environment*, June 2020)

(COVNA STARK, December 2025)



Nanofibers & Electrospinning

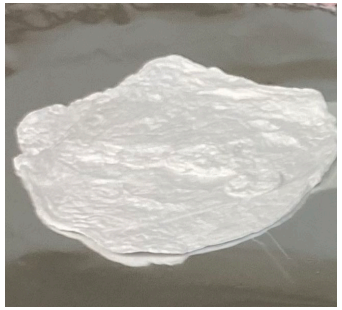
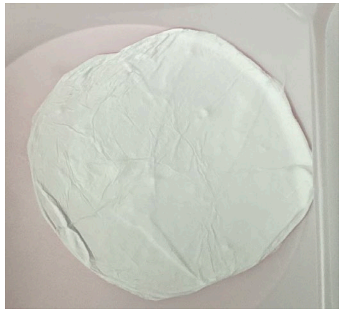
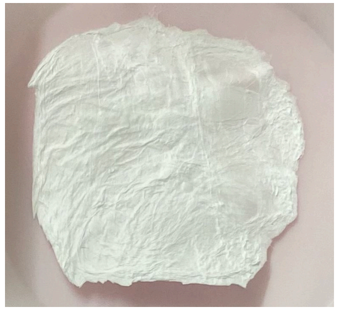
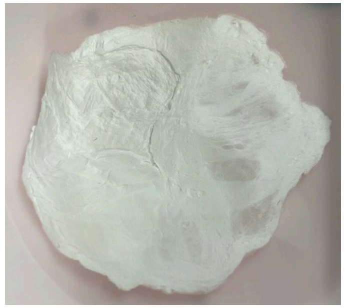
- High voltage draws polymer solution to nm sizes.
- High surface area for adsorption.
- Small pore size for size exclusion.



Survey of Nanomaterial Filters

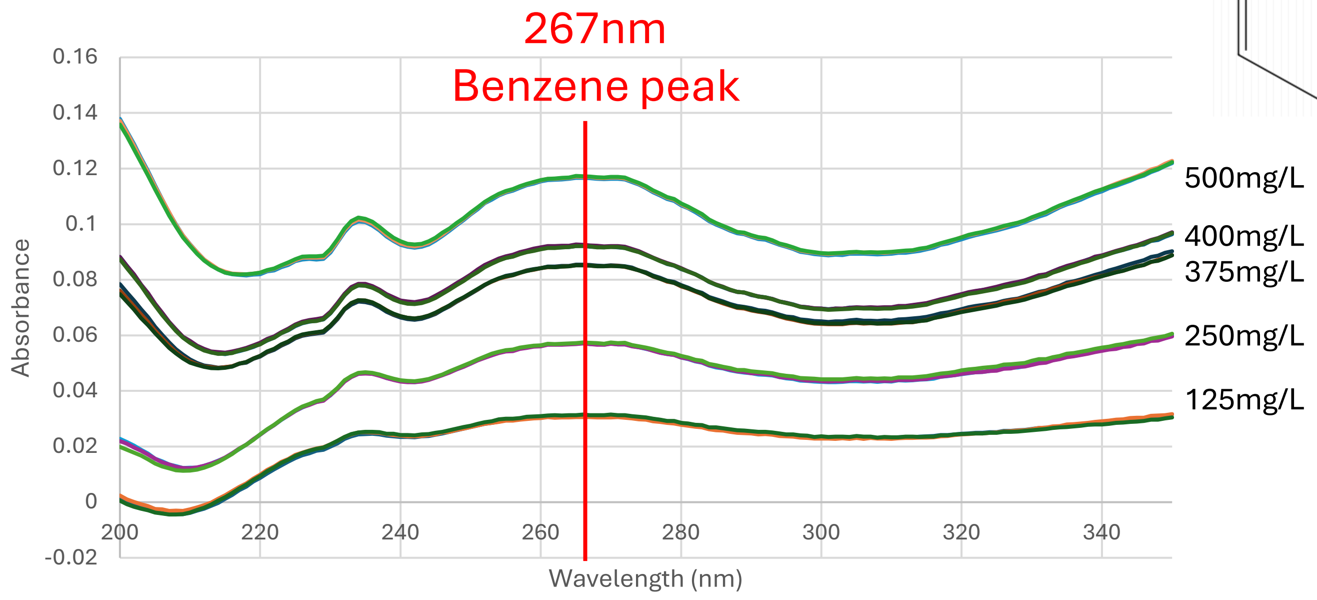
What nanomaterial filters work best for MP removal?

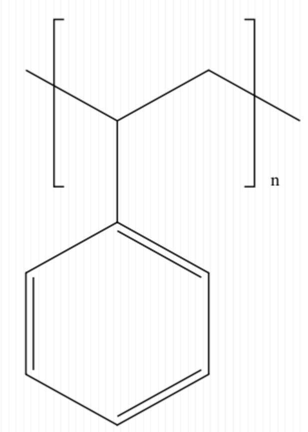
- **What chemistry is best? :** Cellulose Acetate, Cellulose, Chitosan, Polyacrylonitrile (PAN)
- **What morphology is best? :** Membrane or Aerogel

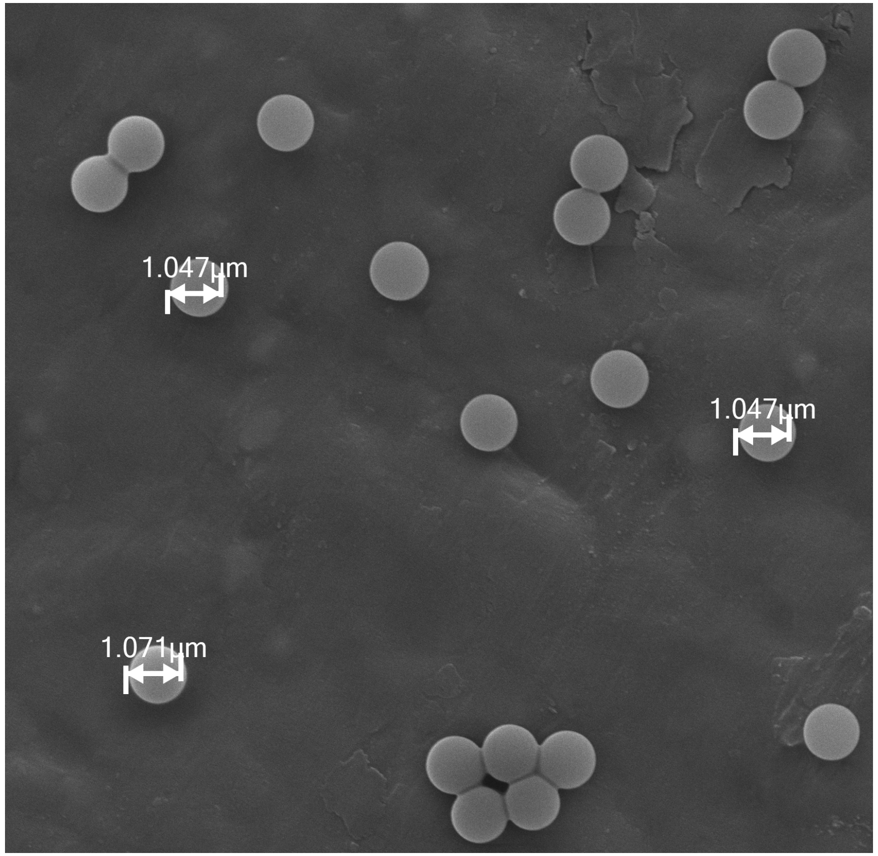
PAN Nanofiber Membrane	PAN Nanofiber Aerogel	Cellulose Acetate Nanofiber Membrane	Cellulose Nanofiber Membrane	Cellulose Nanofiber Aerogel	Cellulose Nanofiber & Chitosan Membrane
					

Microplastic Pollution Model

- 1µm Polystyrene Spheres
- Quantified by UV-Vis

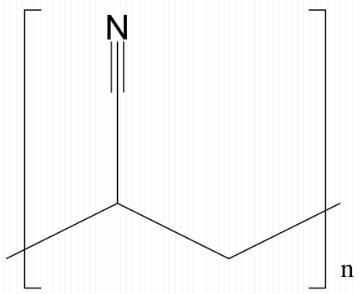


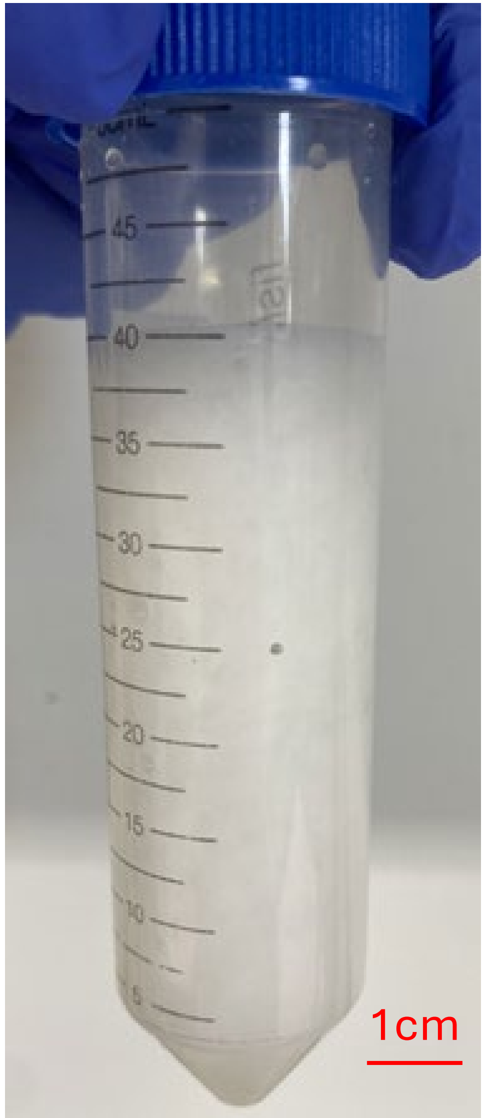


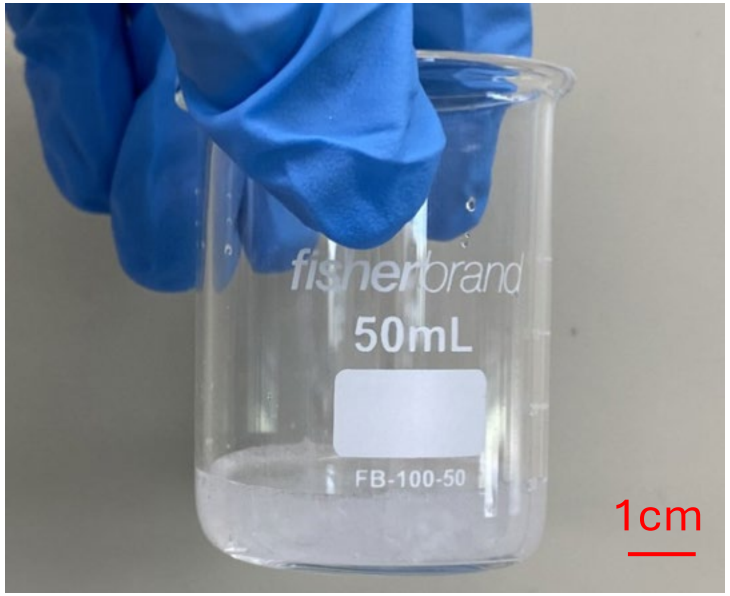


Polyacrylonitrile (PAN) Fibers

- Electrospun in Dimethylformamide (DMF)
  (Zhang, *Journal of Membrane Science*, March 2011)
- Used as membrane and aerogel
- Aerogel formed by ultrasonication → freeze drying







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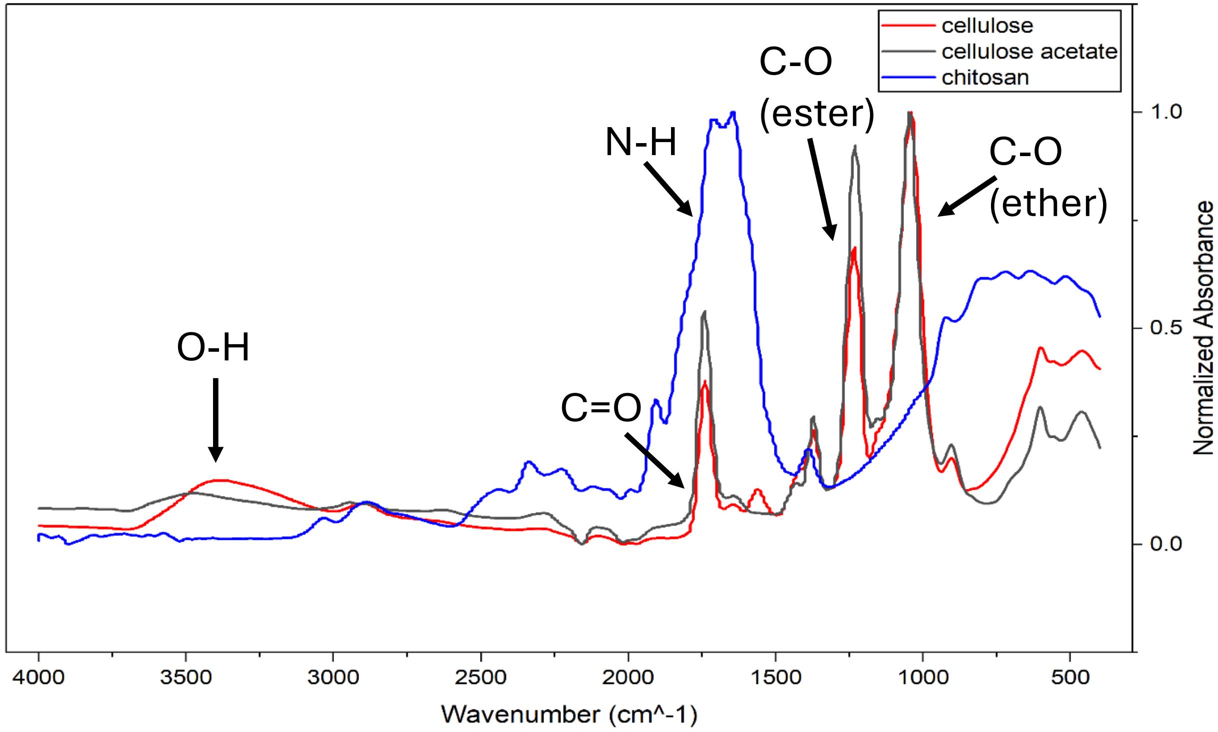
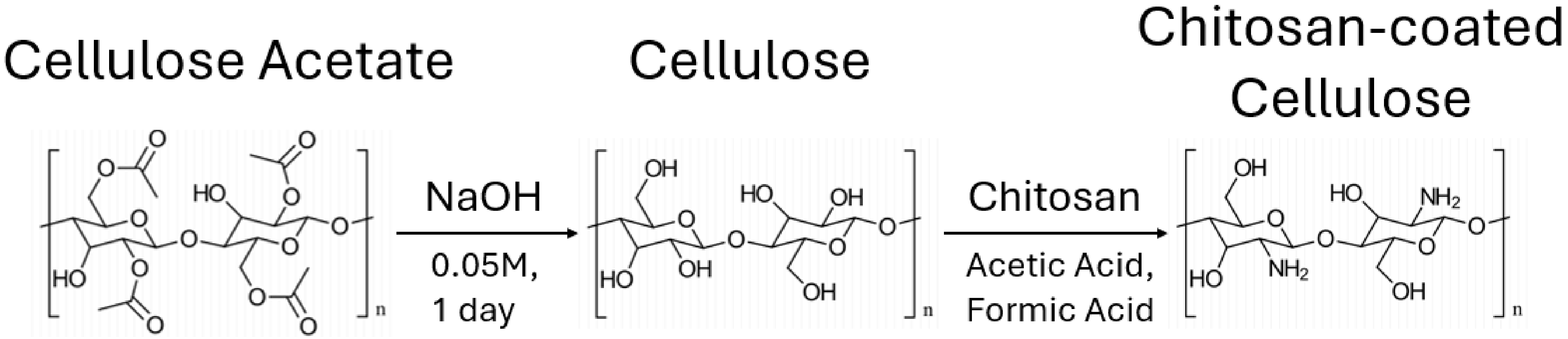
Cellulose Fibers

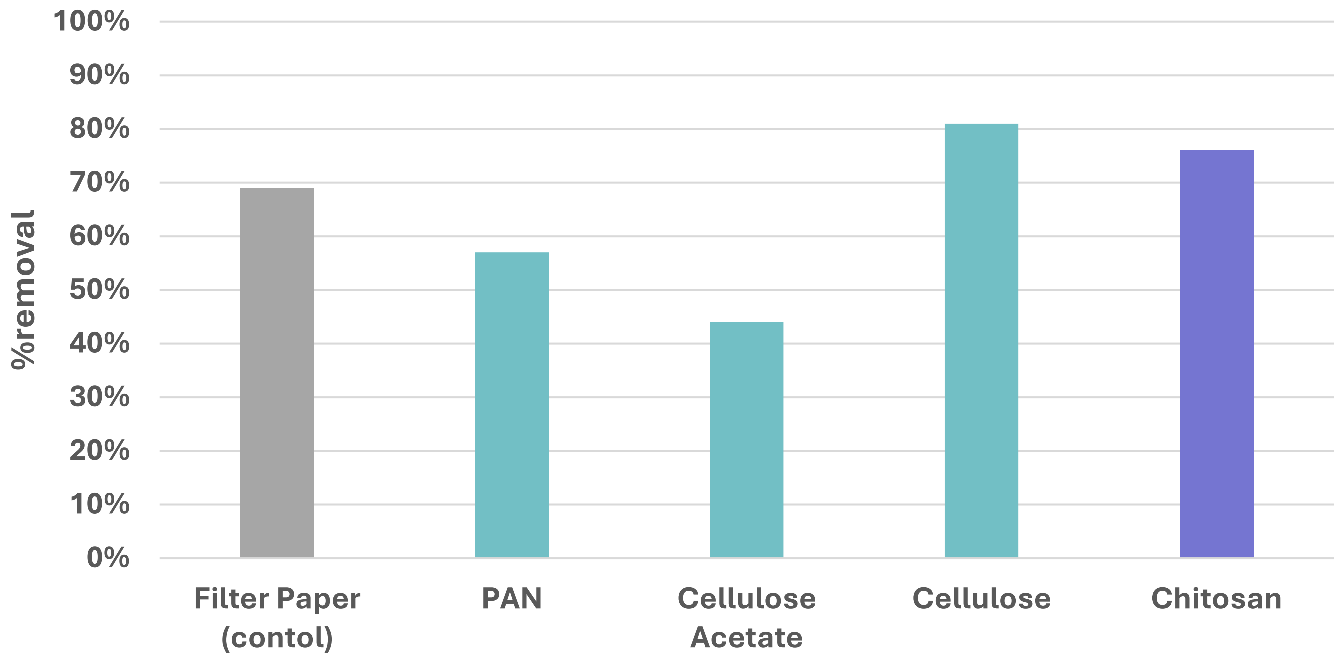
- Cellulose Acetate is directly Electrospun in Acetone and DMSO (Dimethyl Sulfoxide)
- Other cellulose-based materials are formed from Cellulose Acetate Fiber
(Mantripragada, *Cellulose*, June 2023)



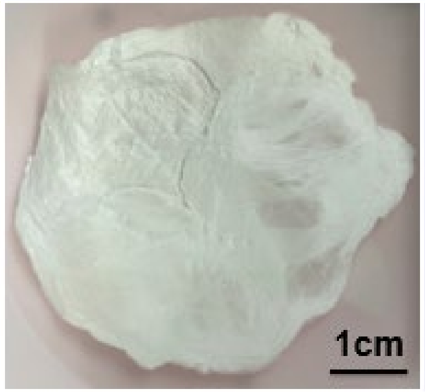


Membrane Performance

- Cellulose performs best
- All filters remove some MP



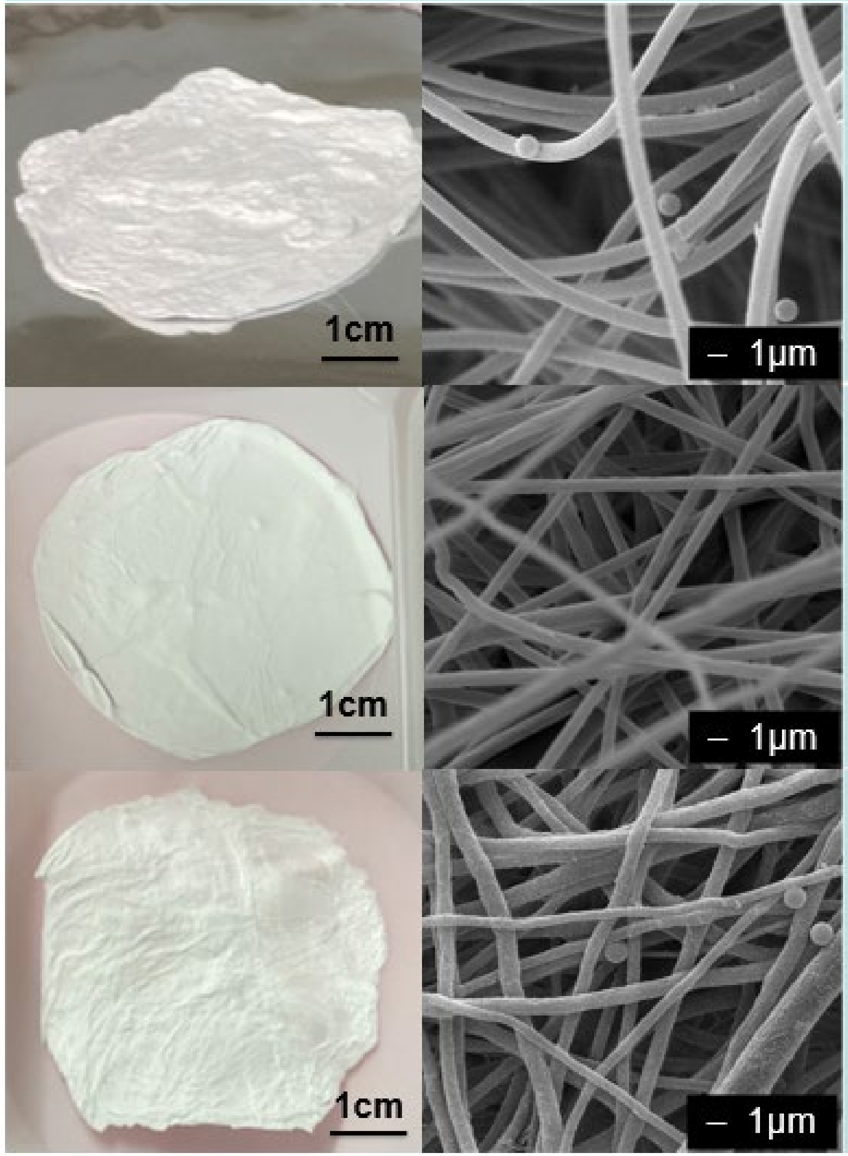
Coated Membranes



Chitosan-Dipped Cellulose

76% MP Removal

Membranes



PAN
57% MP Removal

Avg: 960nm
SD: 90nm

Cellulose Acetate
44% MP Removal

Avg: 957nm
SD: 449nm

Cellulose
81% MP Removal

Avg: 778nm
SD: 366nm

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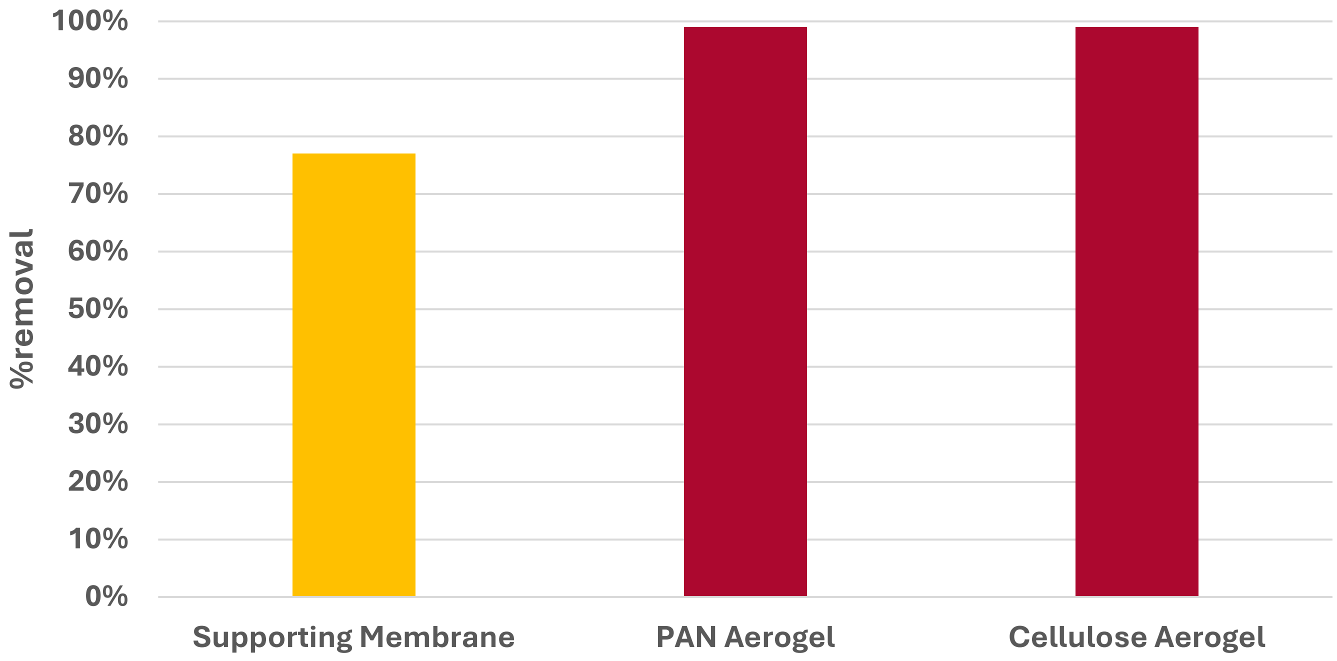
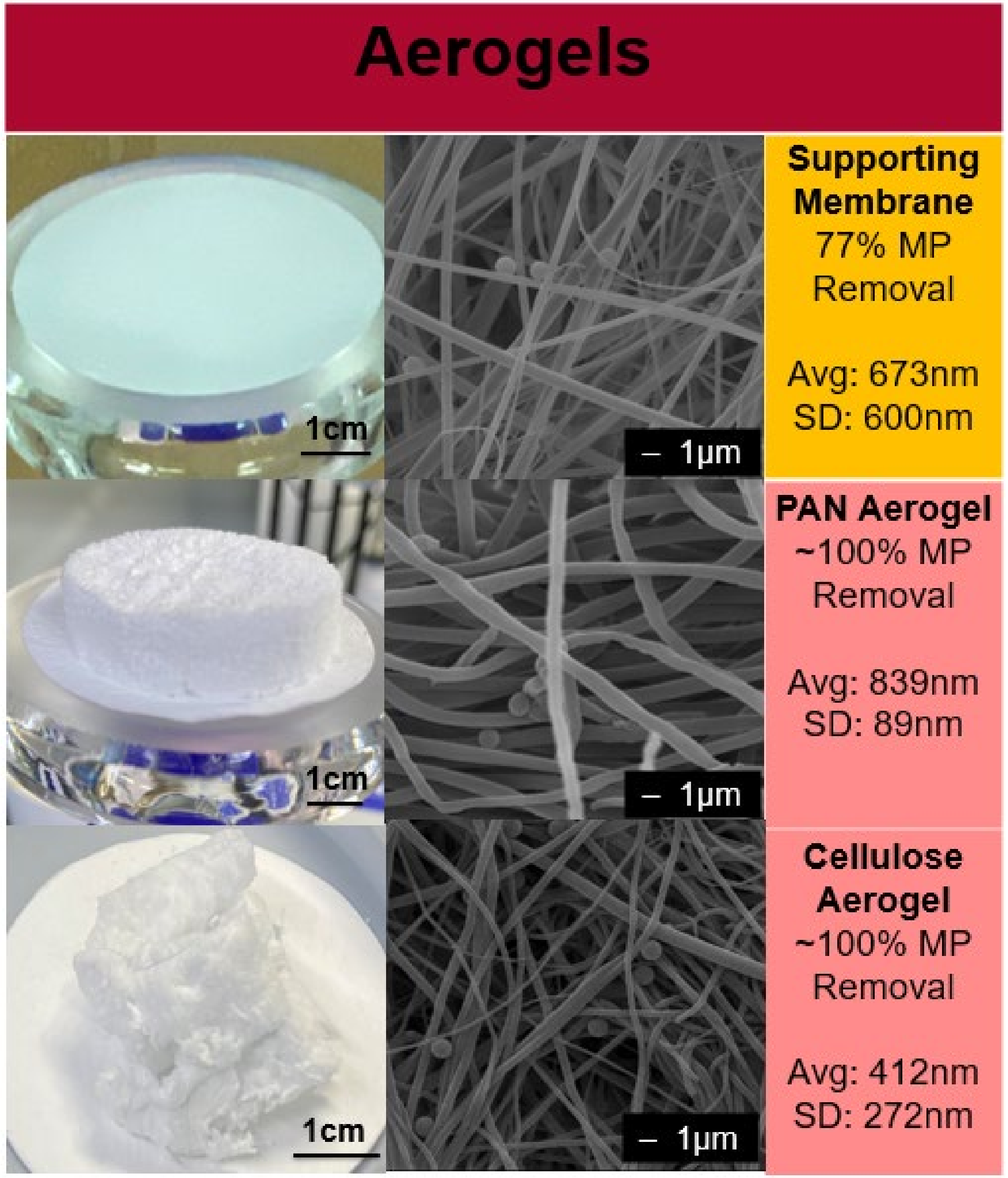
Aerogel Performance

- Aerogels are too weak to test without support
- All aerogels remove ~100% (within resolution of UV-Vis)





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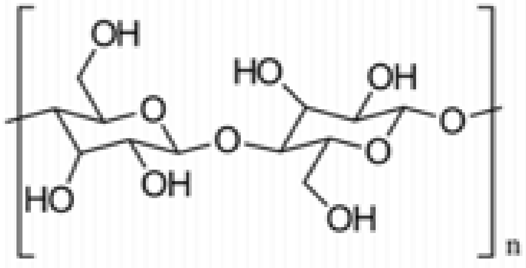
Conclusions

- Hydroxyl groups improve removal significantly
  - Hydrophilicity
  - Aromatic hydrogen bonding *(Schiener et al., JACS, October 2002)*
- Aerogel removes significant MP despite loose/open structure and regardless of chemistry (PAN/cellulose)
- Future Work:

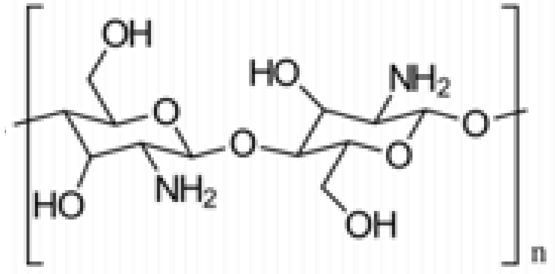
  -Crosslinked Aerogels

  -MP detection at lower concentration

Successful Materials (high -OH)

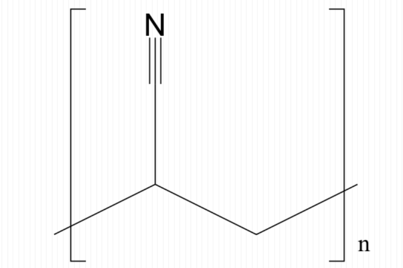


cellulose

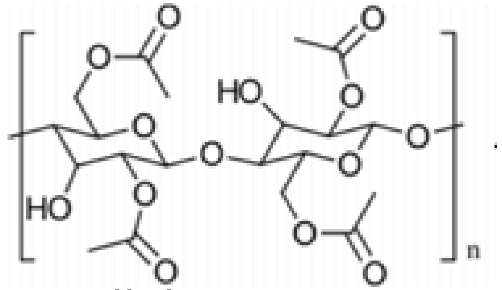


chitosan

Unsuccessful Materials (low -OH)



PAN



cellulose acetate

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Acknowledgements

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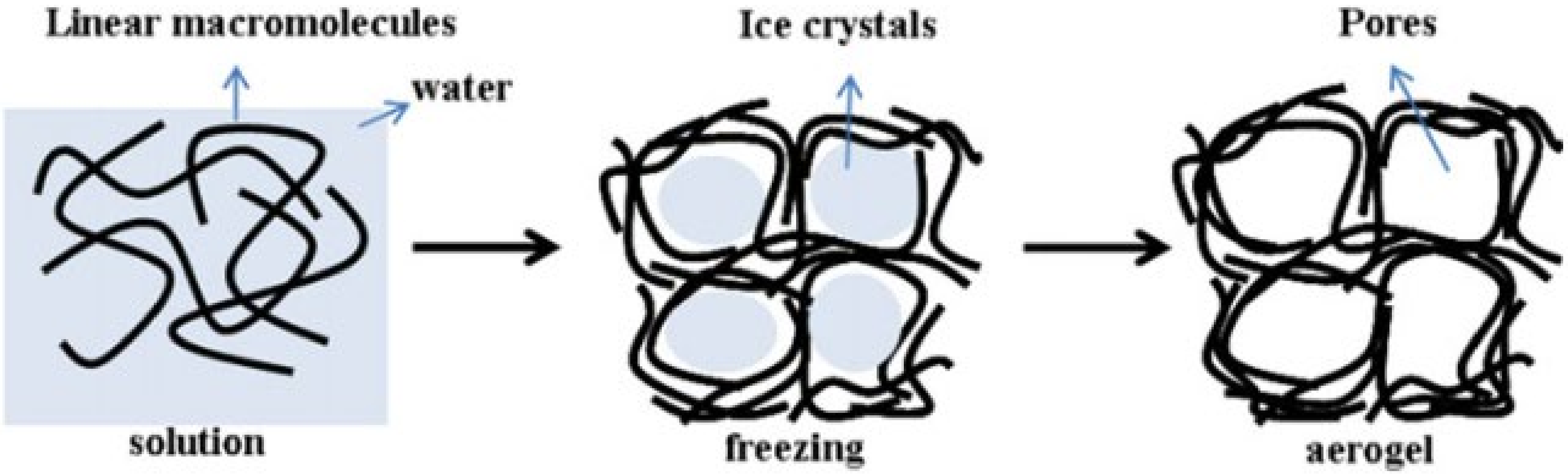
Supplemental:

- Aerogel Pore Formation
- Additional SEM of Aerogels

Aerogel Formation and Freezing

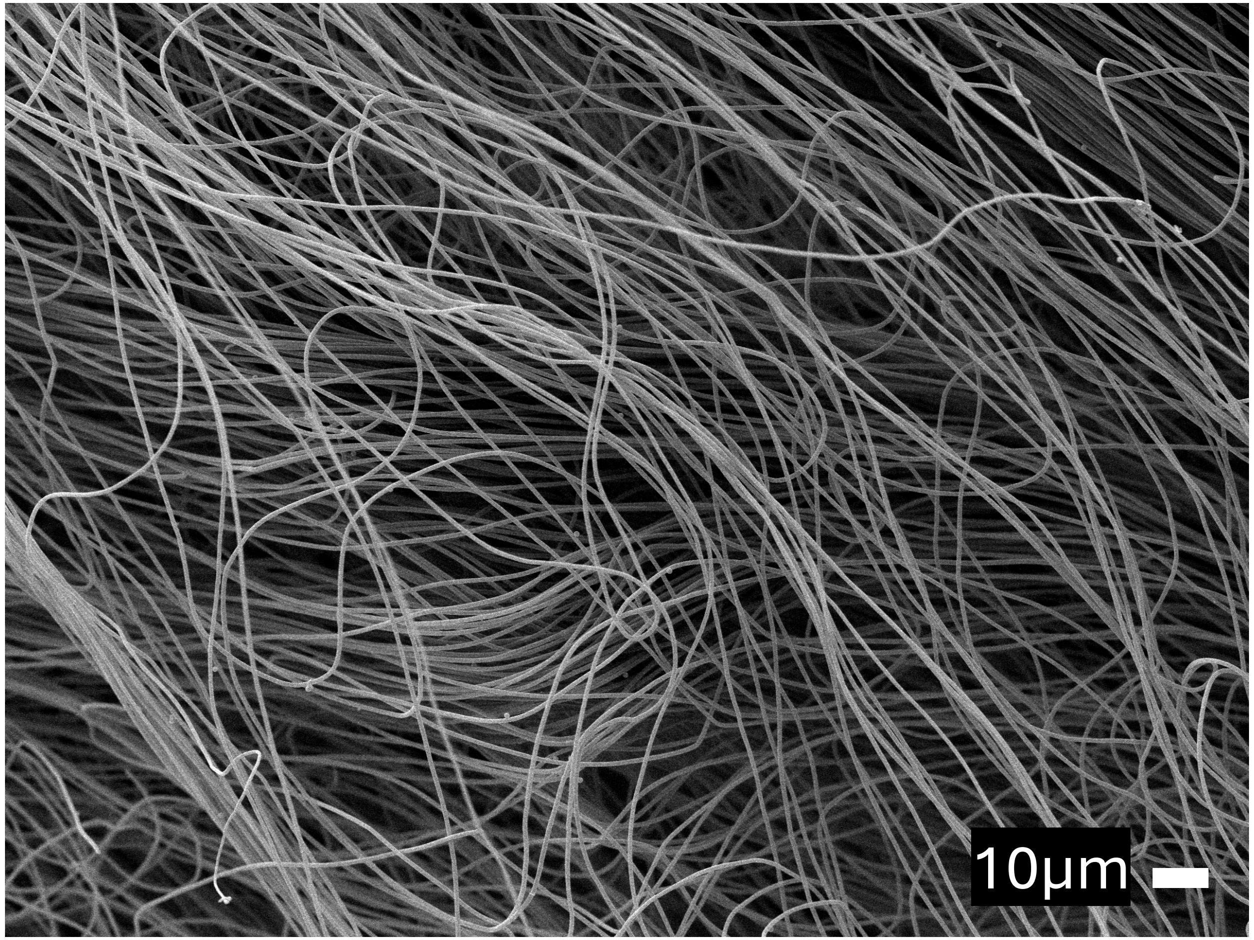
- Ice crystals open microscale pores but compact nanofibers.
- Freezing instantly in liquid nitrogen rather than freezer may create smaller ice crystals and finer porosity.



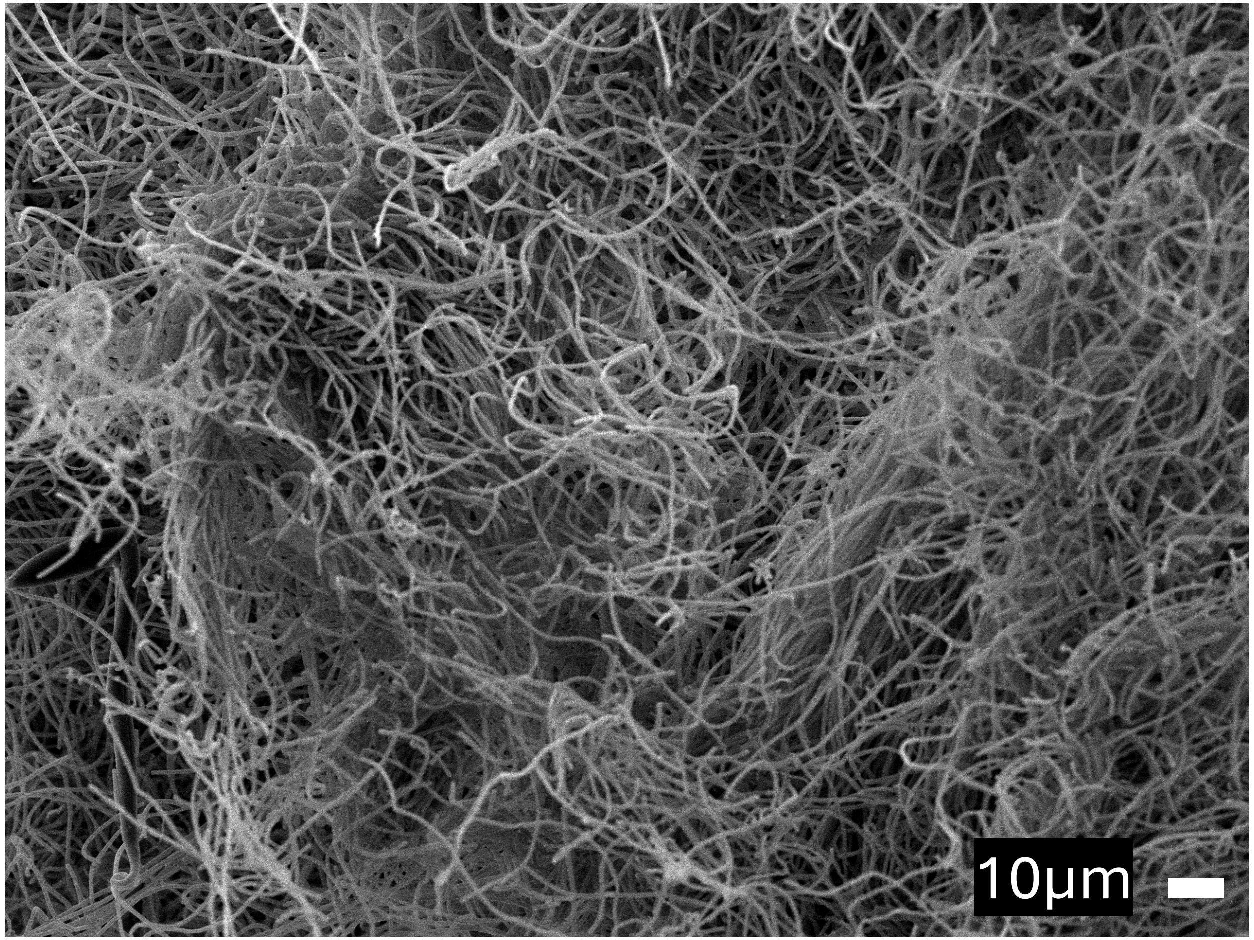
Yixin Wang, Xi Chen, Ying Kuang, Man Xiao, Yuehong Su, Fatang Jiang, Microstructure and filtration performance of konjac glucomannan-based aerogels strengthened by wheat straw, *International Journal of Low-Carbon Technologies*, Volume 14, Issue 3, September 2019, Pages 335–343, https://doi.org/10.1093/ijlct/ctx021

Zoomed Out Aerogel Pictures

- Morphology differences easier to see at lower magnification



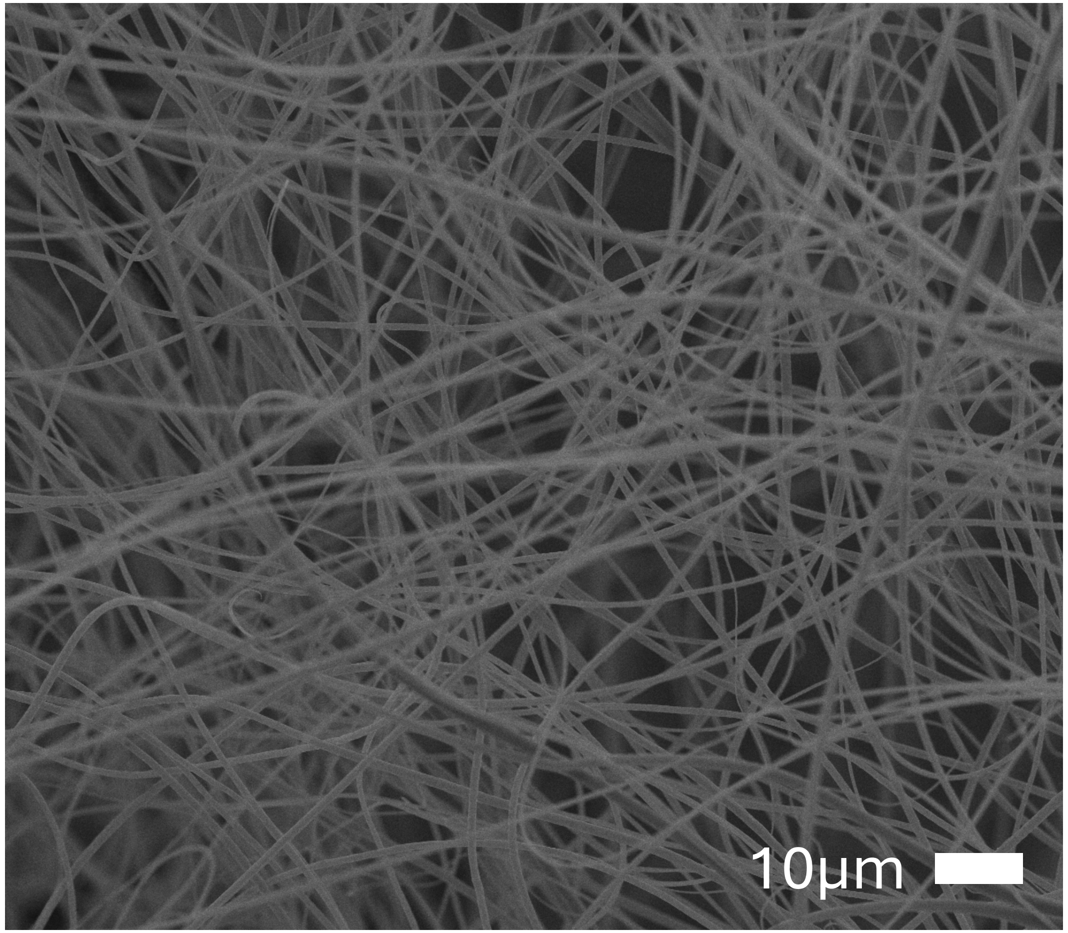
PAN fiber



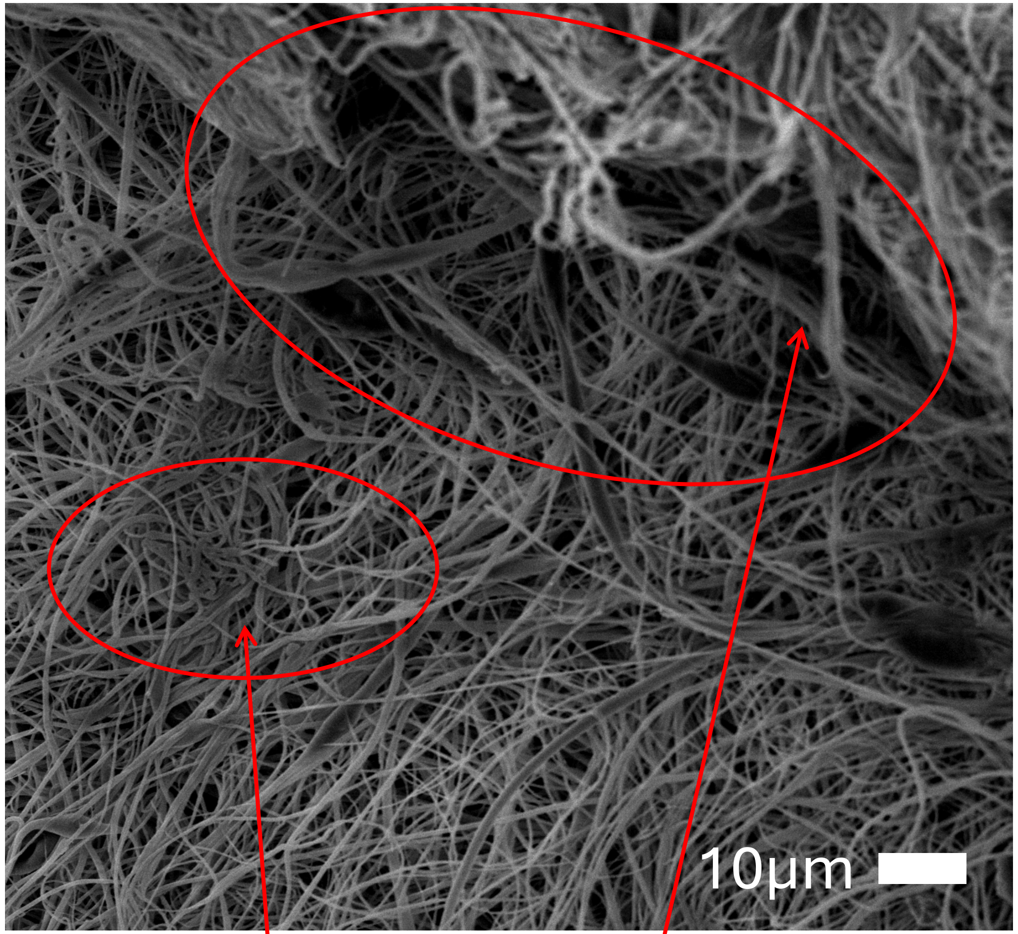
PAN Aerogel

Zoomed Out Aerogel Pictures

Cellulose fiber



Cellulose Aerogel



Aerogels look denser at nm scale, but are more open/porous as micrometer scale

Dense fiber
at pore wall

Large opening/unevenness
at microscale