Gradual Desaltation of Complex Coacervates Using Microfluidics to Develop a Novel Class of Porous Fibers

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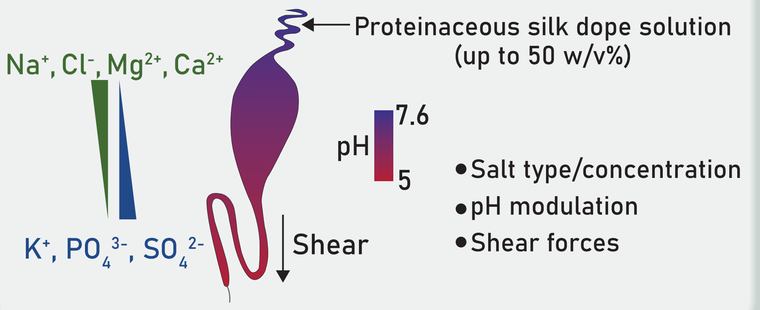
Aim: Bioinspired Fabrication of Tough Fibers

- Spiders can manipulate the local environment within the silk gland allowing for the transformation of a proteinaceous solution into tough silk.
- Goal of this work is to take inspiration from this mechanism by gradually modifying ionic strength of complex coacervates in microfluidic chips.
- Microfluidics may allow for the development of novel, strong yet tough fibers via a green processing approach.

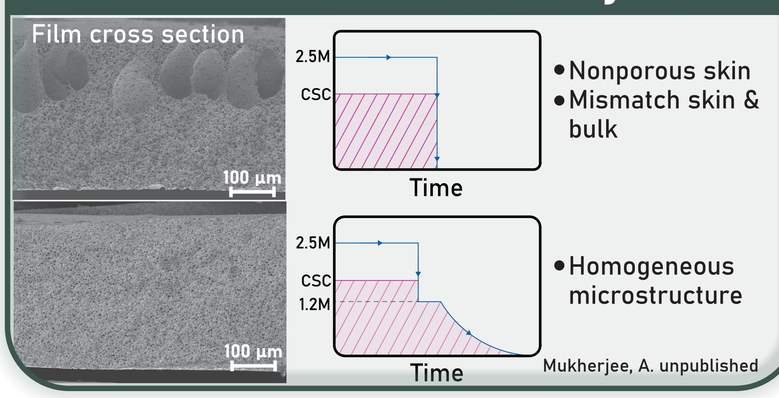
Spider Silk Mimicry



- Salt type/concentration
- pH modulation
- Shear forces

Malay, A. et al. **2022**
Rising, A. et al. **2015**

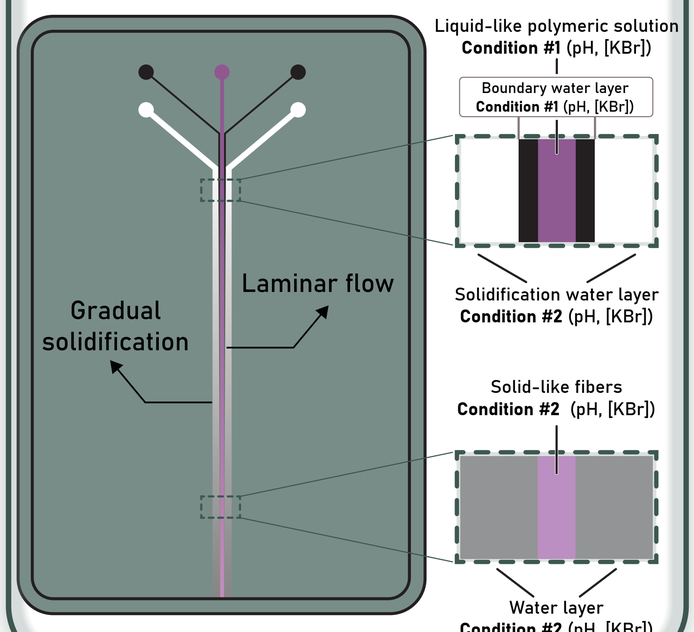
Tunable Porosity



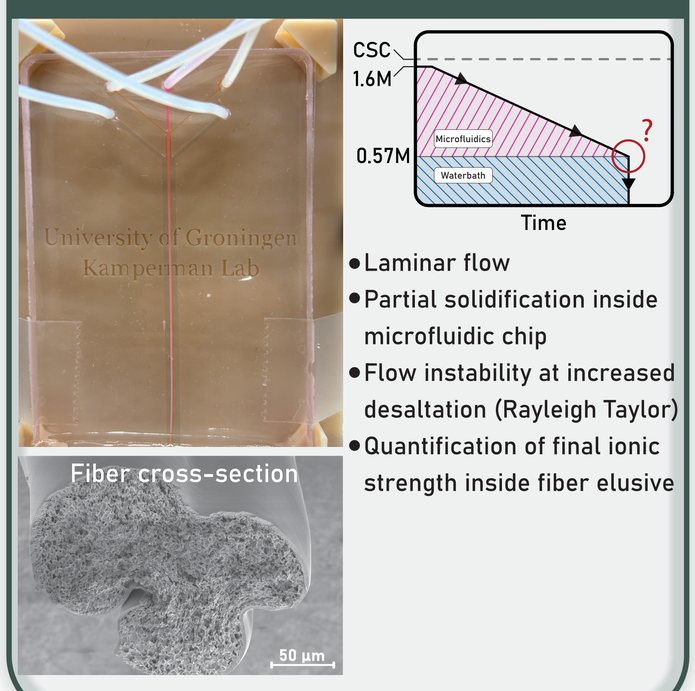
- Nonporous skin
- Mismatch skin & bulk
- Homogeneous microstructure

Mukherjee, A. unpublished

Concept

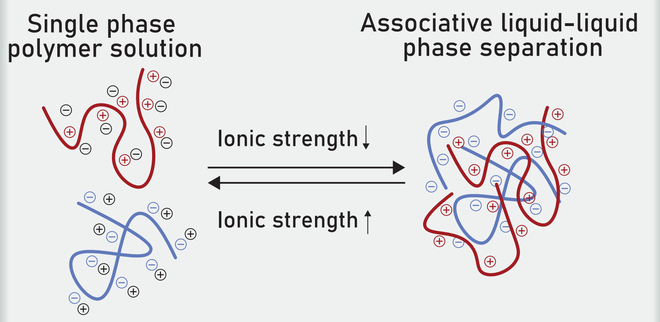


Fiber Formation

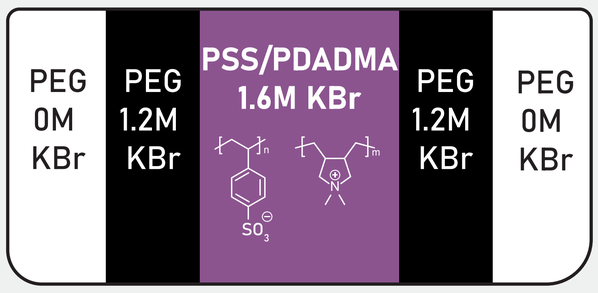


- Laminar flow
- Partial solidification inside microfluidic chip
- Flow instability at increased desaltation (Rayleigh Taylor)
- Quantification of final ionic strength inside fiber elusive

Complex Coacervation



Viscoelastic fluid ⇌ Stiff polyelectrolyte complex

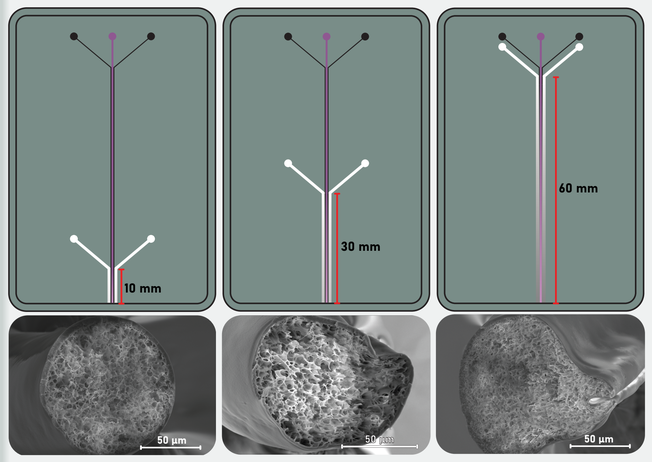


Abbas, M. et al. **2021**

Outlook

- Partial desaltation of complex coacervate achievable using microfluidics
- Follow up work includes:
  - Shear alignment of polymer chains
  - Reduce PEG content in outer flows
  - Investigate role of PEG as a macromolecular crowder

Inflow Position



- Shorter equilibration distance equals rounder fibers
  - Fibers enter water bath more liquid-like
- Longer equilibration distance results in larger fibers (77µm | 82µm | 117µm respectively)
  - Water enters coacervate

References

[1] A. D. Malay, H. C. Craig, J. Chen, N. A. Oktaviani and K. Numata, Biomacromolecules **2022**, 23, 1827-1840.
[2] A. Rising and J. Johansson, Nature Chemical Biology **2015**, 11, 309-315.
[3] M. Abbas, W. P. Lipinski, J. Wang and E. Spruijt, Chem Soc Rev **2021**, 50, 3690-3705.
[4] A. Mukherjee, unpublished results