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The University Of Sheffield.

Push or pull: how does silk flow?

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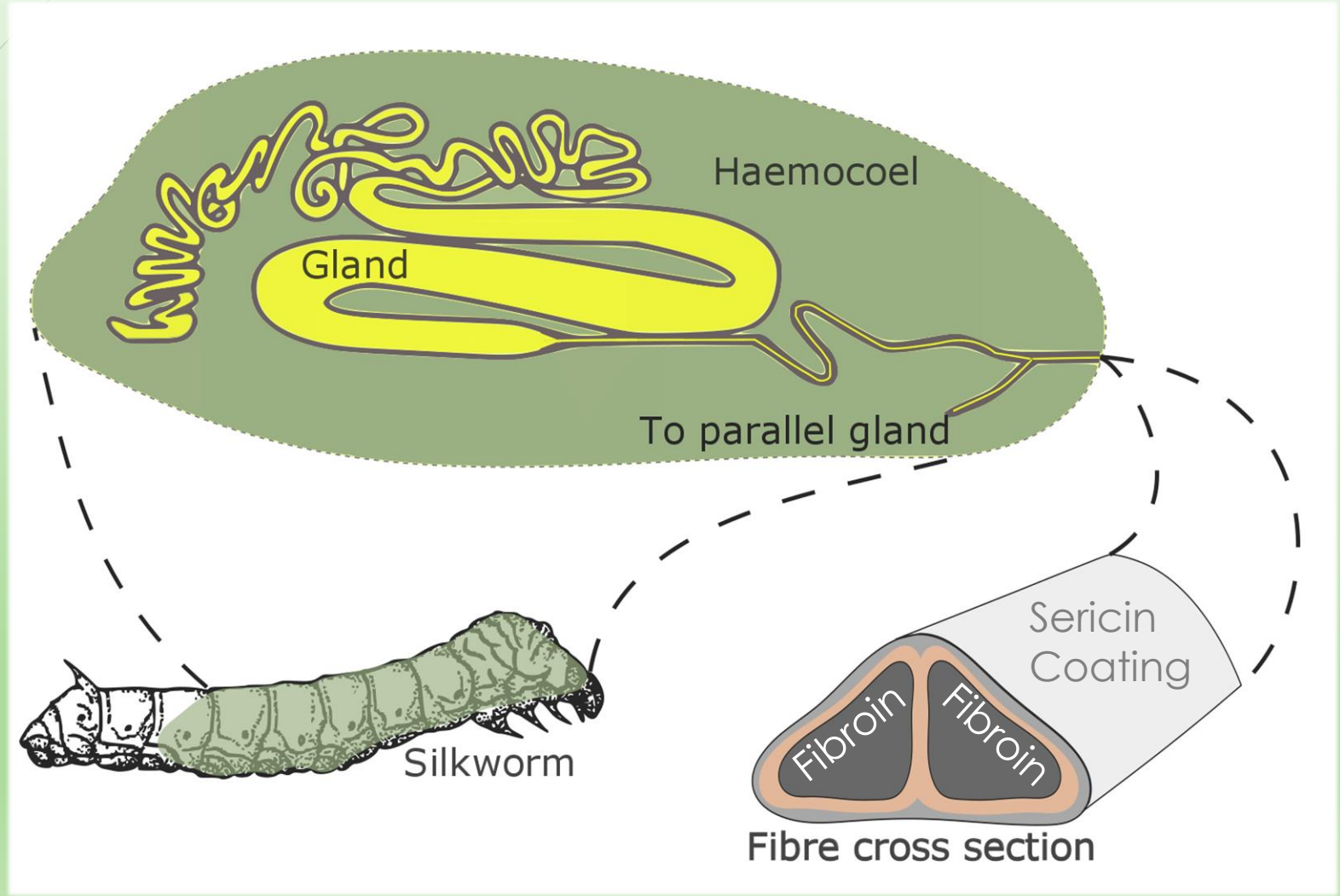
natural materials group

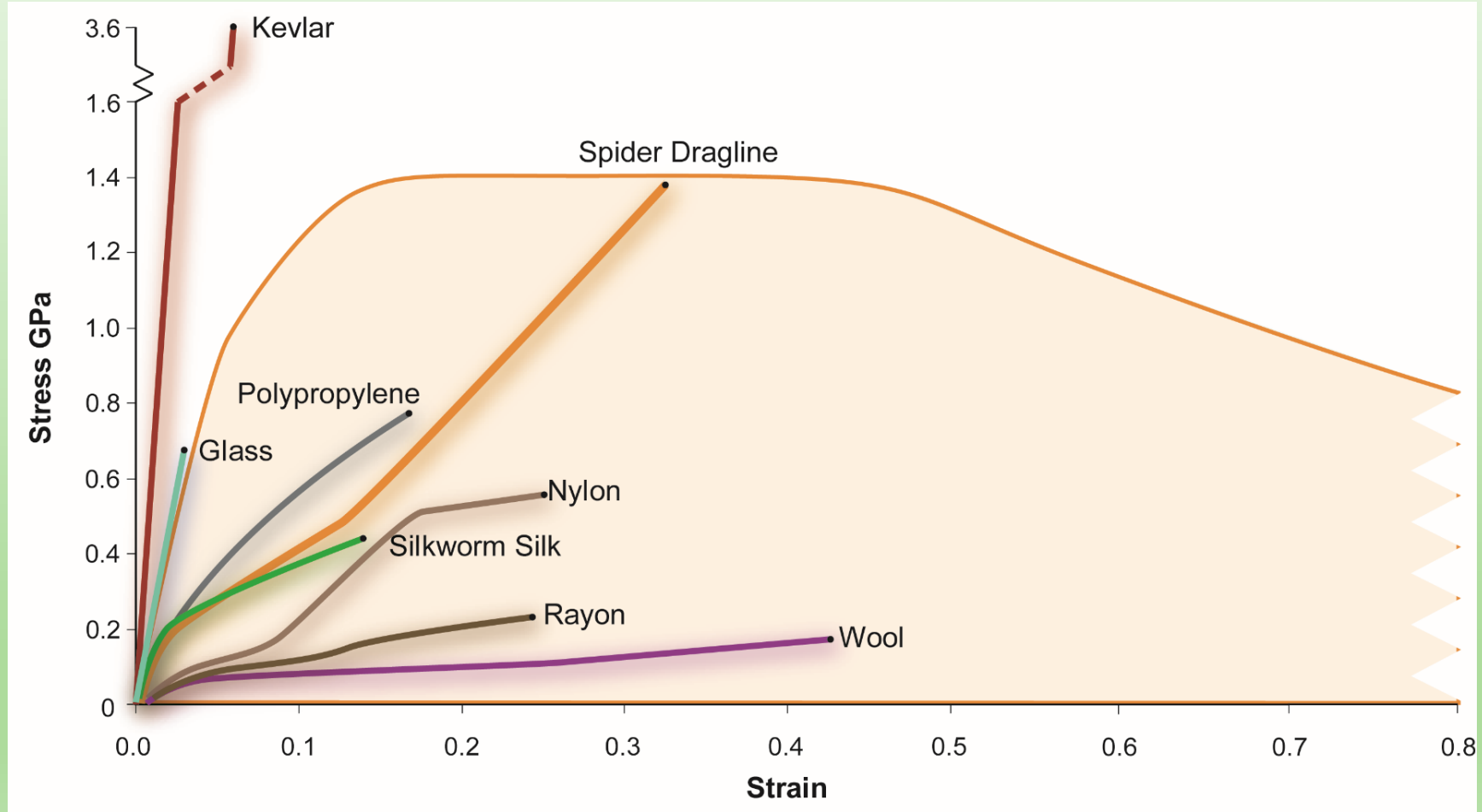
Contents

Introduction – Where are silks from?

Introduction – what are silks?



Why we are interested in silk

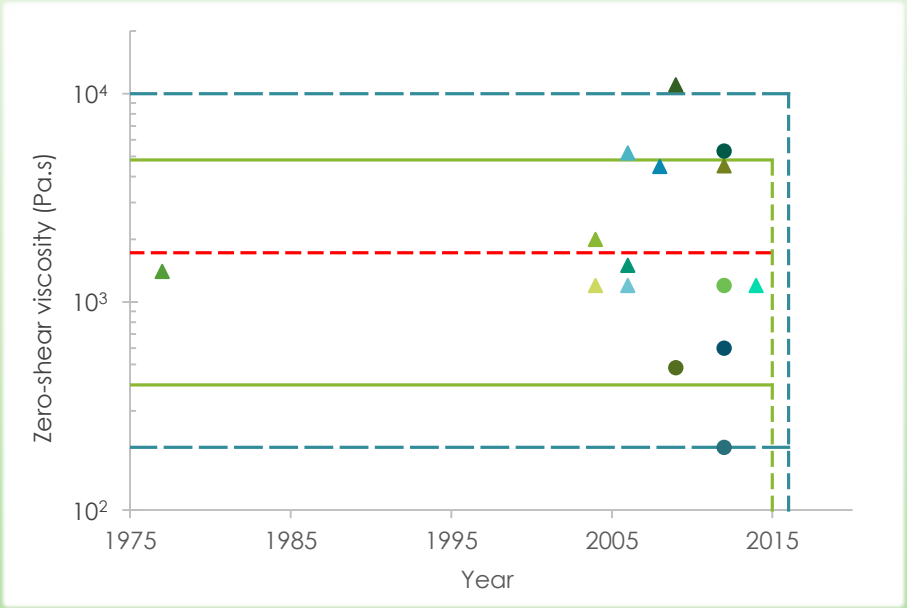


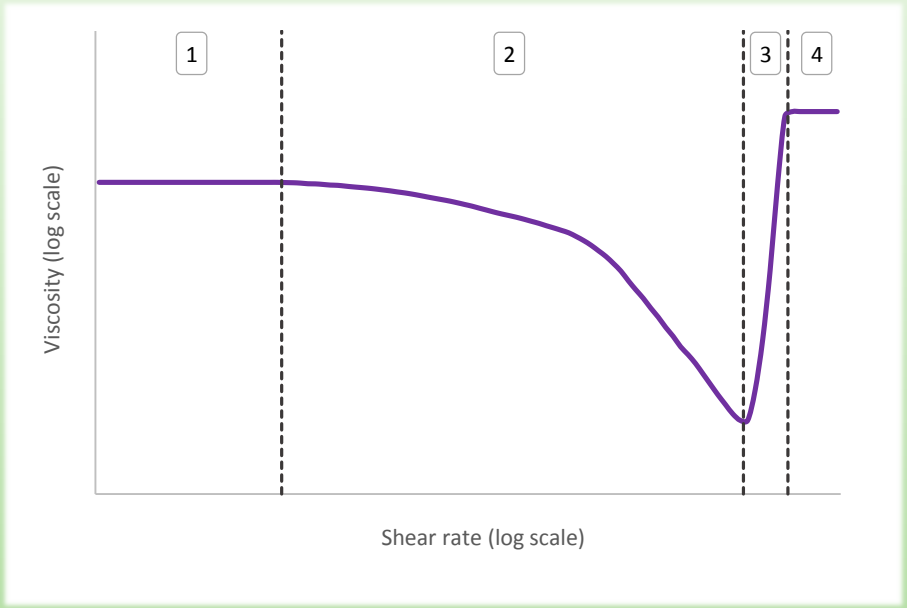
Vollrath et al., 2013

Aims and objectives

- Explore how geometric and fluid properties affect silk spinning
- Identify which parameters are crucial for spinning silk
- Define a pressure based spinning domain
- Determine whether silk is extruded (pushed) or pultruded (pulled).

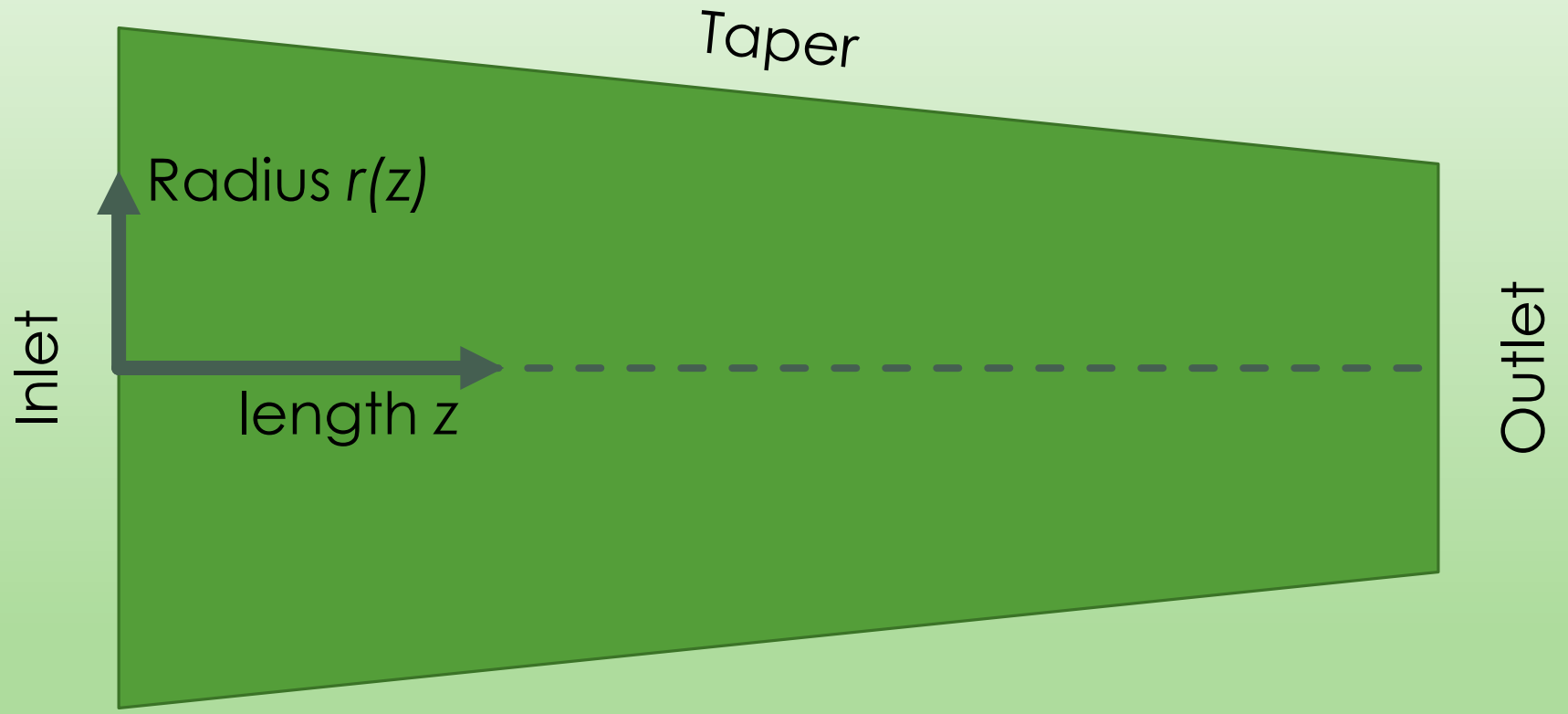
Fibroin rheology



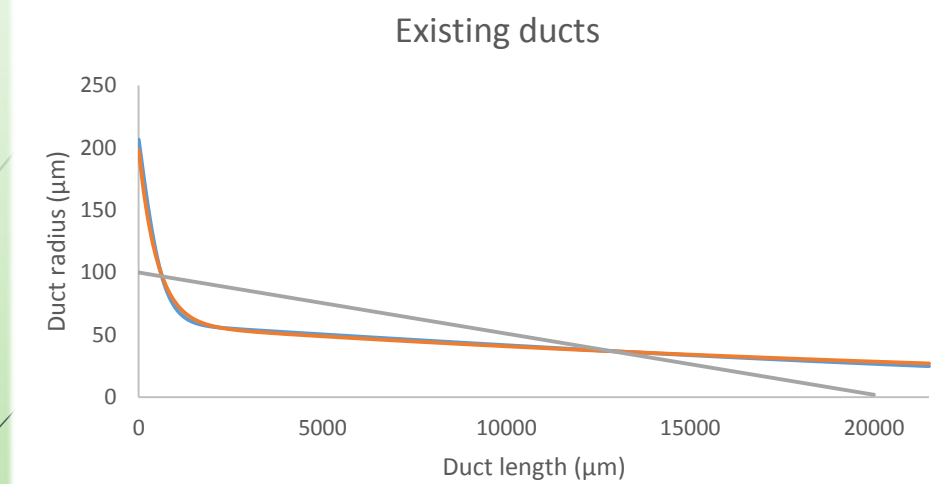


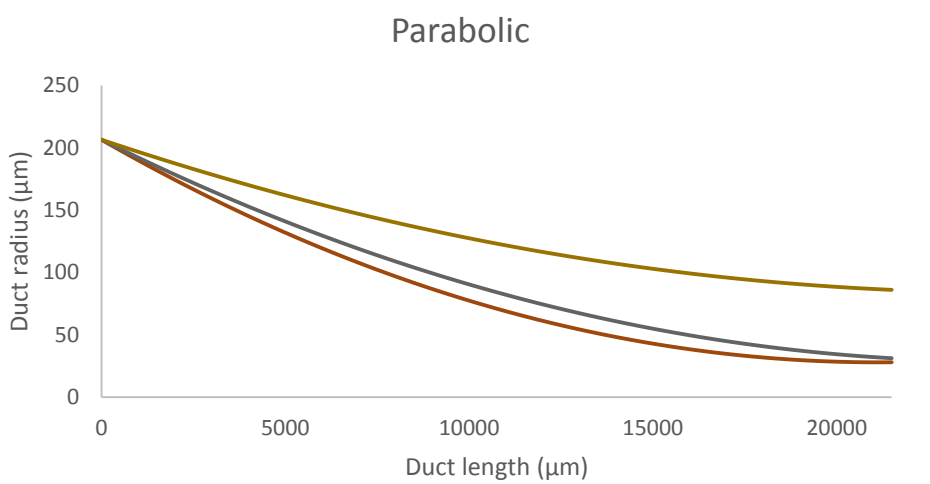
$$\eta(\dot{\gamma}) = \eta(\dot{\gamma}) = \eta_0(1 + (\lambda\dot{\gamma})^a)^{\frac{n-1}{a}} \lambda)^{\frac{n-1}{a}}$$

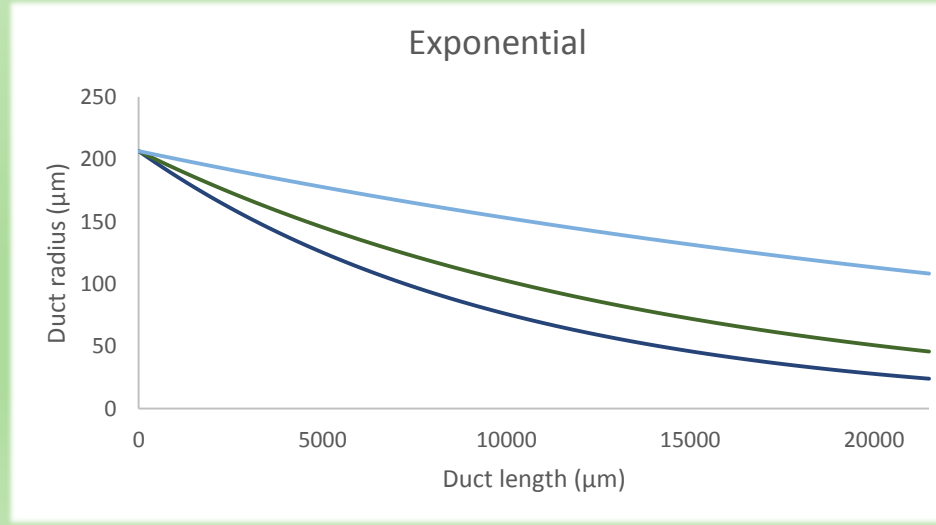
Duct geometries – general form

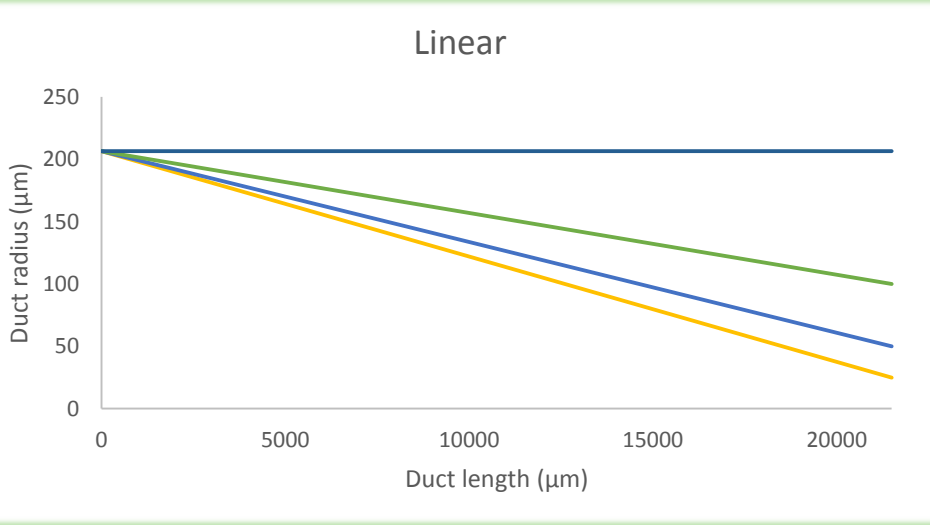


Duct geometries

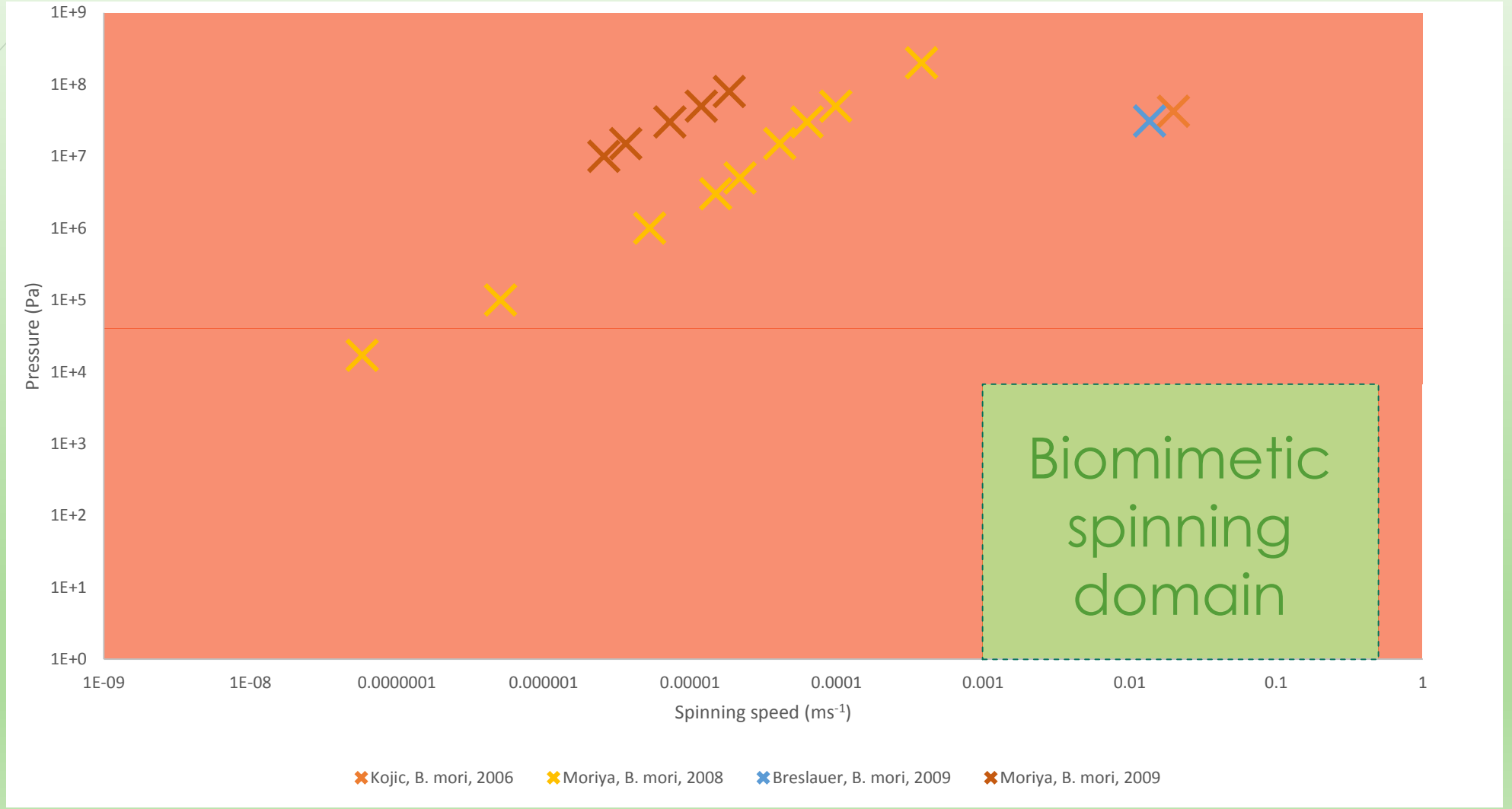








Results: Summary of biomimetic spinning domain



Methods

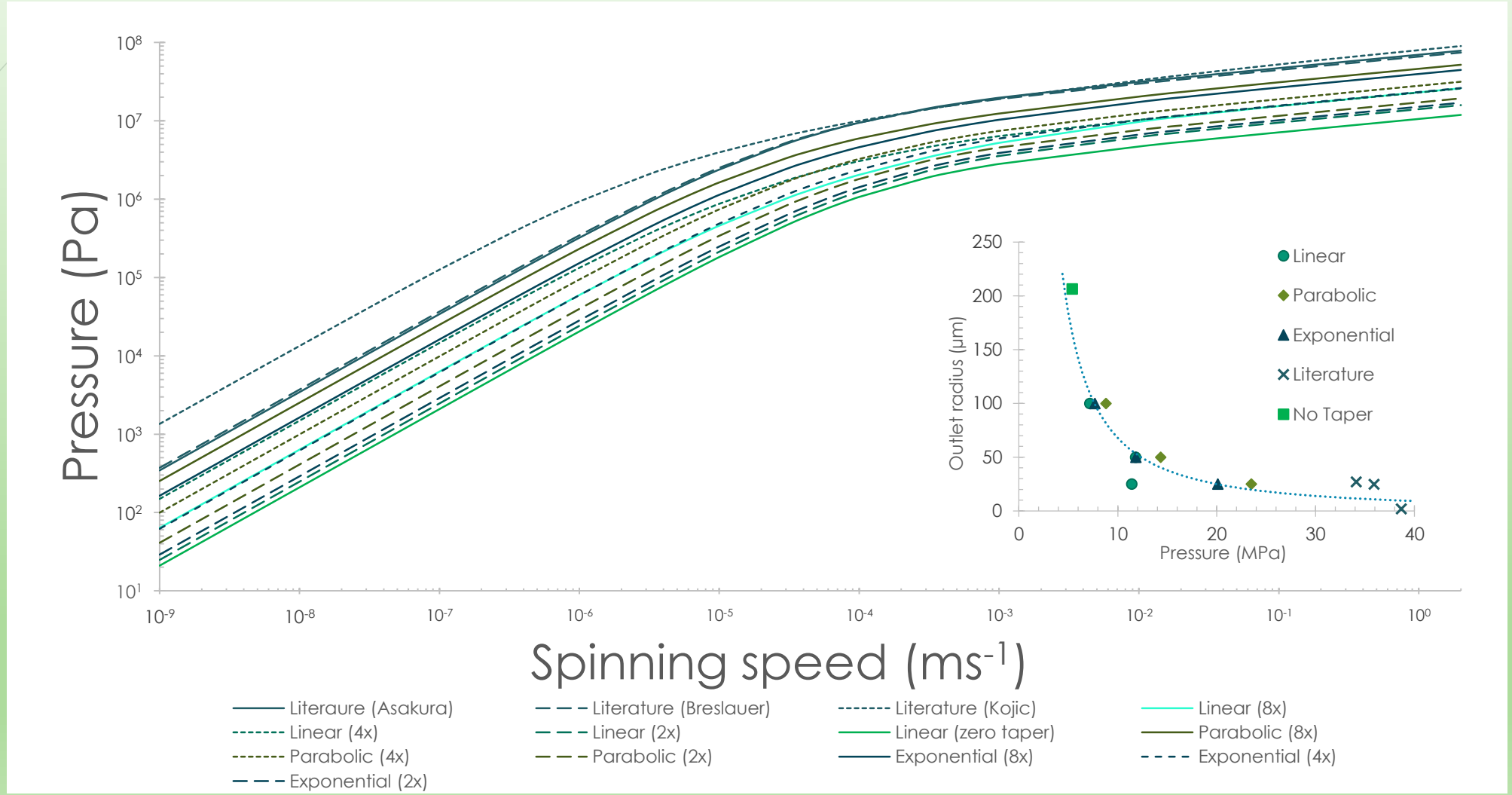
Geometric taper
- Hyperbolic
- Exponential
- Parabolic
- Linear

Model conditions:
- Generalised Navier-Stokes equations
- Slip/No slip boundary
- Axisymmetric, Laminar flow

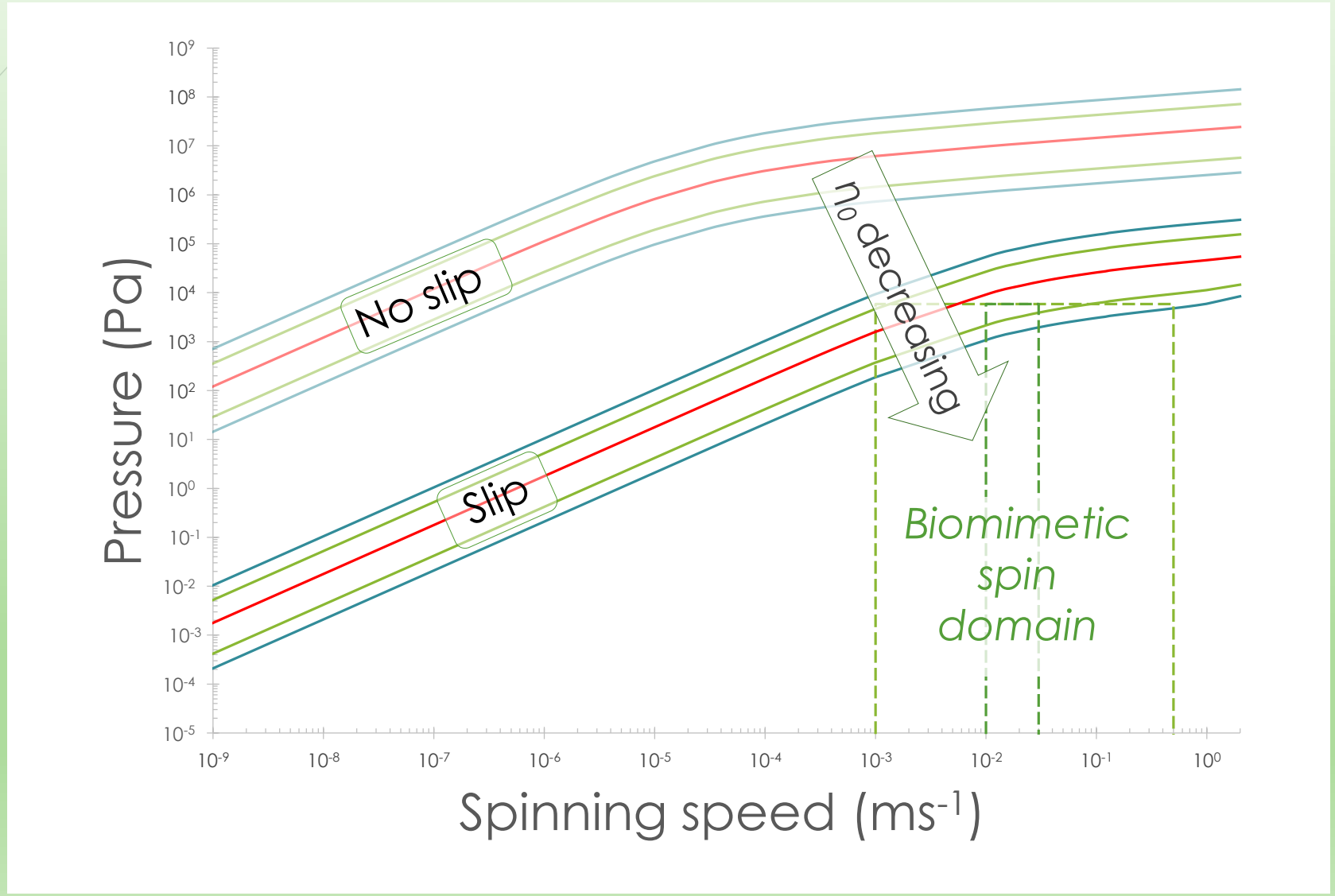
Rheology
Shear thinning fluid – Simplified Carreau-Yasuda model.

COMSOL Multiphysics – CFD module

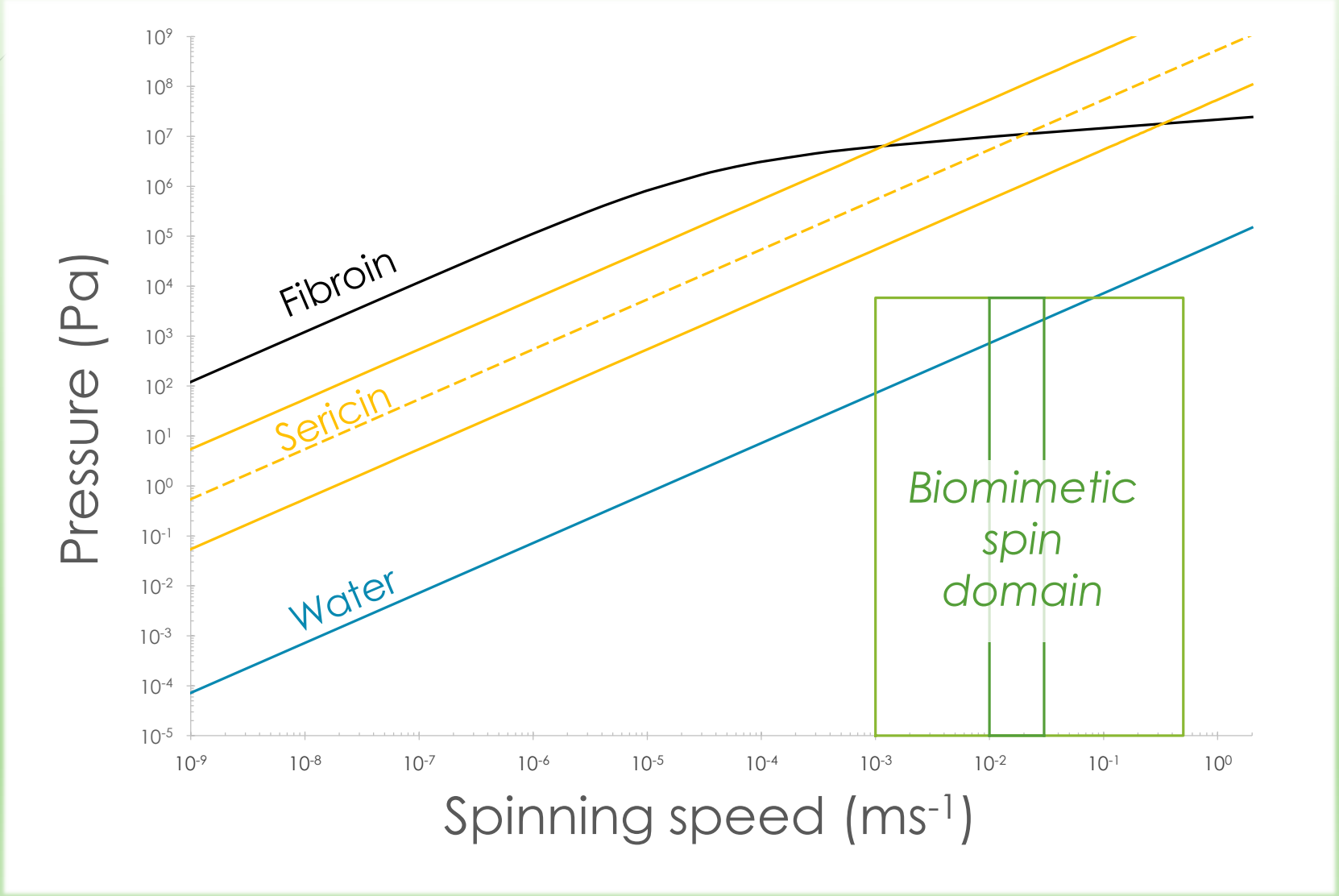
Results - geometric effects.



The effect of changing the zero shear viscosity



Changing the fluid



Conclusions

- Lower pressure requirements can come from:
  - Reduced wall friction
  - Larger outlet
  - Less dramatic tapers
  - Lower zero-shear viscosity
- Generated pressure cannot be directed.
- Silk is ***pulled*** from the gland.
- Single phase models are not sufficiently accurate.

Next steps

- Develop two phase flow models
- Rheological characterisation of sericin

Acknowledgements

- Dr Chris Holland, Dr Pete Laity, and the rest of the Natural Materials Group for their help and guidance

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The University Of Sheffield.

EPSRC

natural materials group

Any questions?

Either way, thanks for listening.