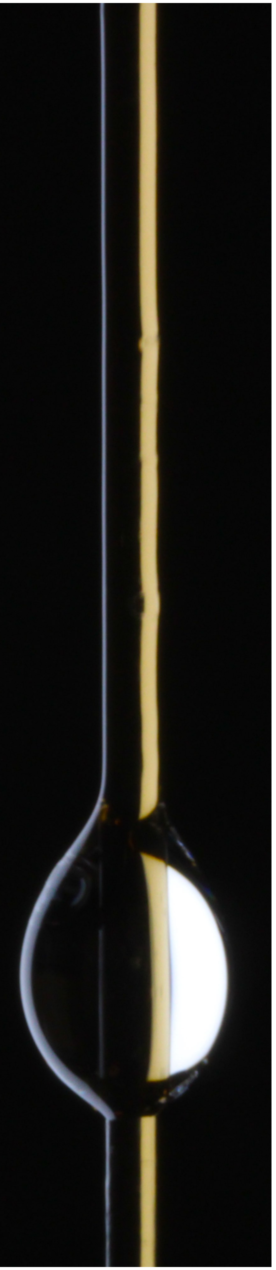


SPEED AND VOLUME MEASUREMENTS OF DROPLETS SLIDING ON VERTICAL FIBERS.

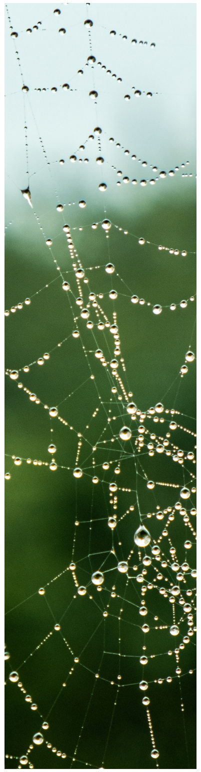
Fog, Fog Collection & Dew Conference 2023

LEONARD Matteo

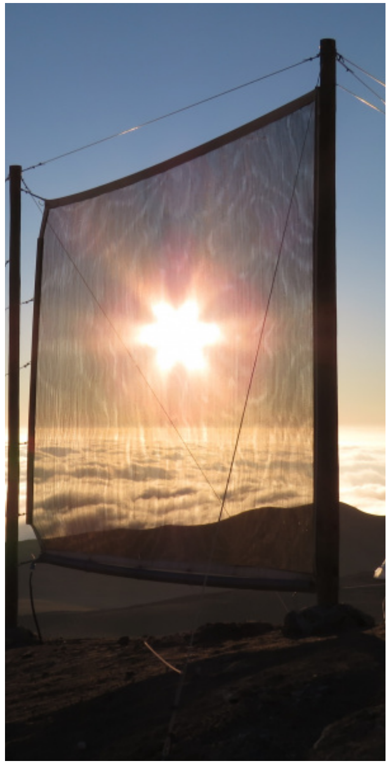
23 July 2023

Passive Water Harvesting

Inspiration



Tools



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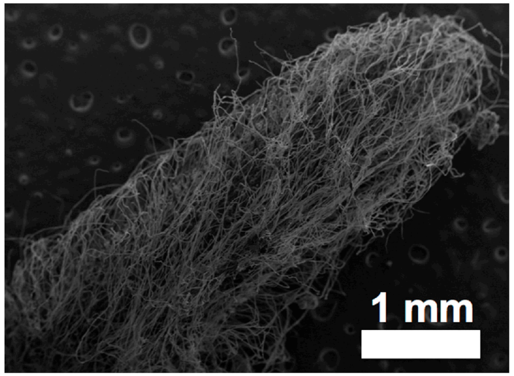
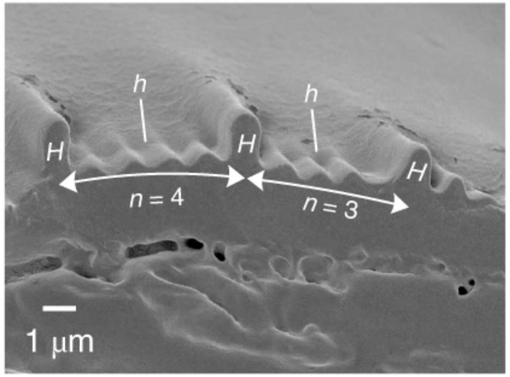
Substructure Era

Hairs



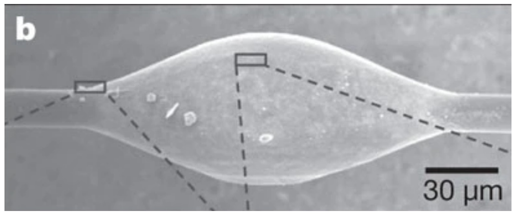
Gürsoy, M., et al. "Bioinspired fog capture and channel mechanism based on the arid climate plant Salsola crassa." *Colloids and surfaces a: physicochemical and engineering aspects* 529 (2017): 195-202.

Grooves



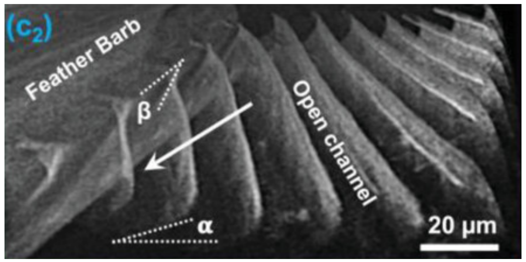
Chen, Huawei, et al. "Ultrafast water harvesting and transport in hierarchical microchannels." *Nature materials* 17.10 (2018): 935-942.

Knots

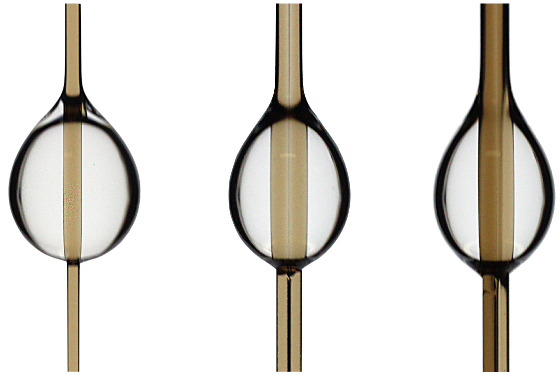


Zheng, Yongmei, et al. "Directional water collection on wetted spider silk." *Nature* 463.7281 (2010): 640-643.

Wedges



Luan, Kang, et al. "Spontaneous directional self-cleaning on the feathers of the aquatic bird anser cygnoides domesticus induced by a transient superhydrophilicity." *Advanced Functional Materials* 31.26 (2021): 2010634.



Does fibre substructure impacts droplet dynamic ?

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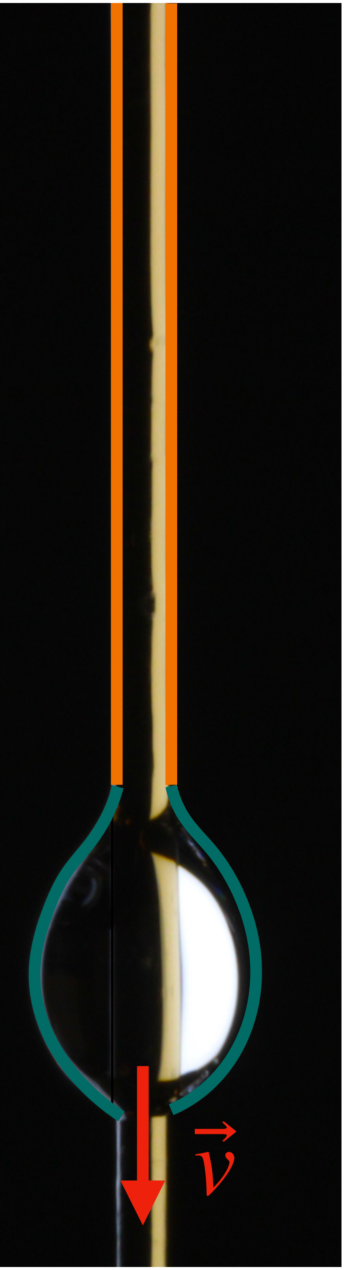
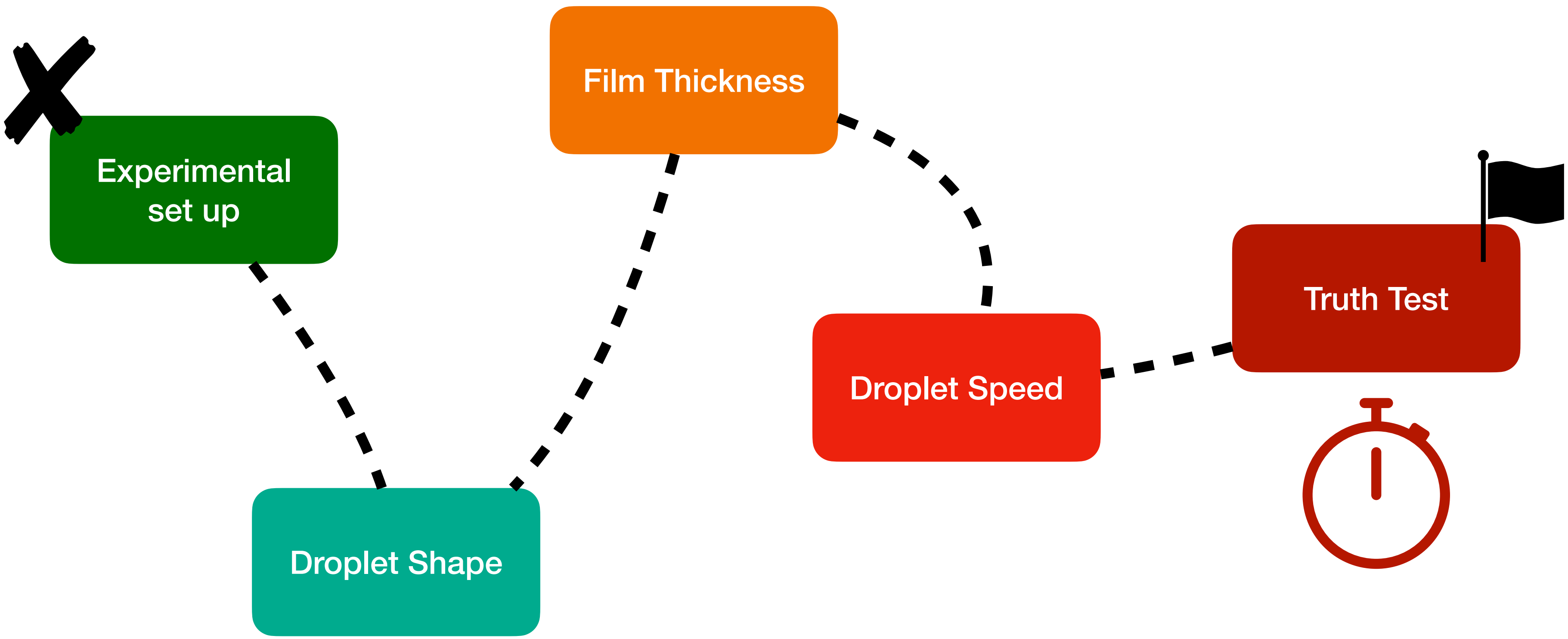
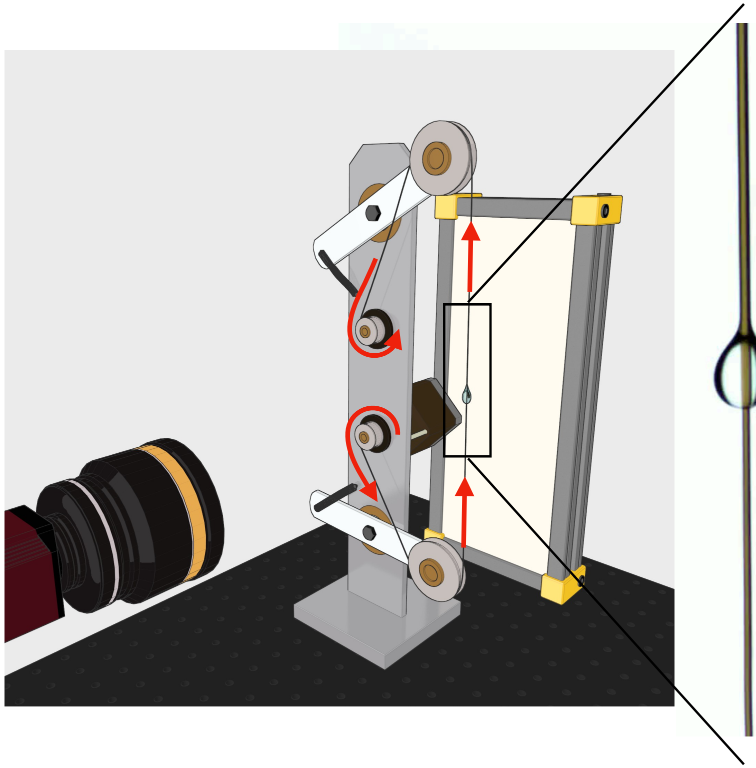
Does fibre substructure impacts droplet dynamics ?

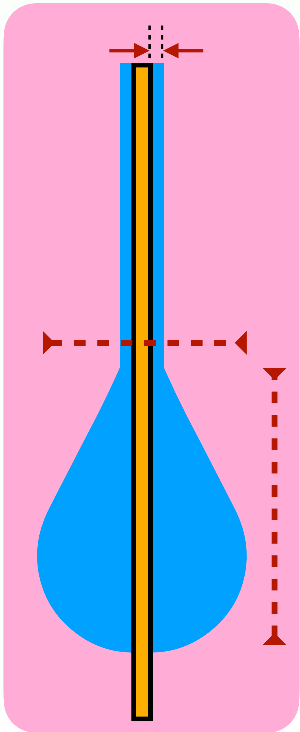




Experimental Set Up



Observables



Film Thickness

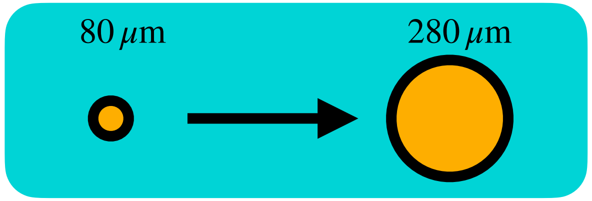
Geometry

Speed

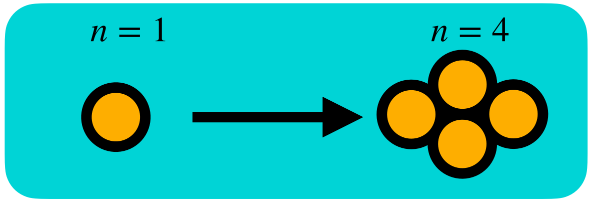
Volume

Variables

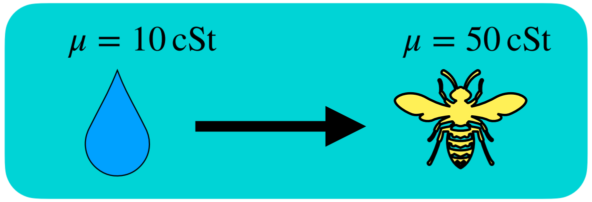
Fibre Diameter



Fibre number



Silicone Oil Viscosity



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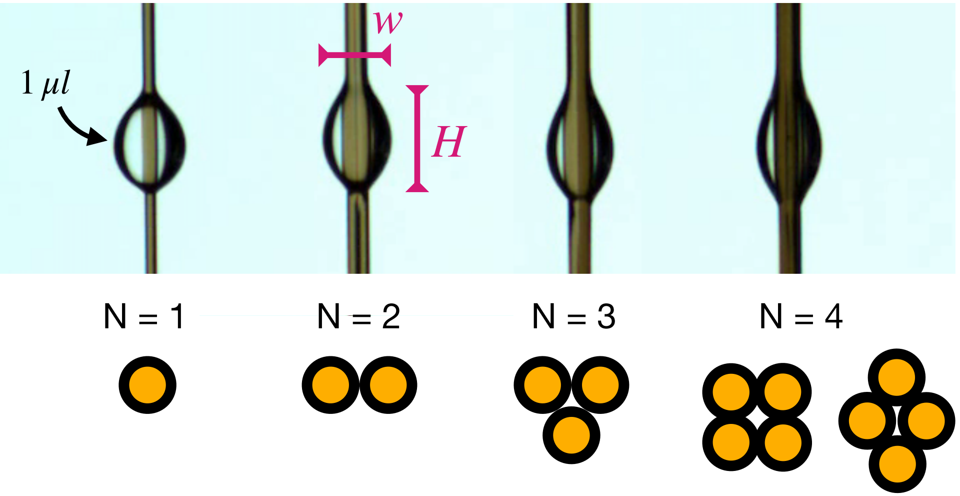
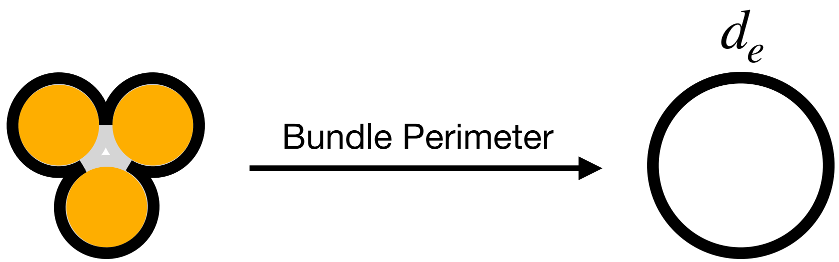
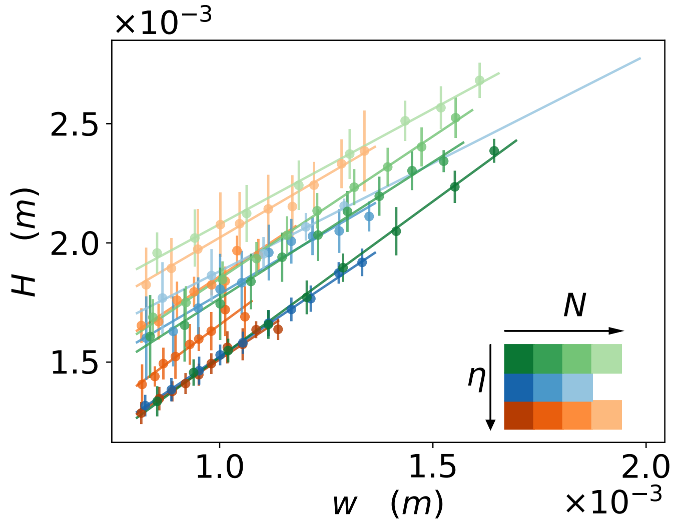
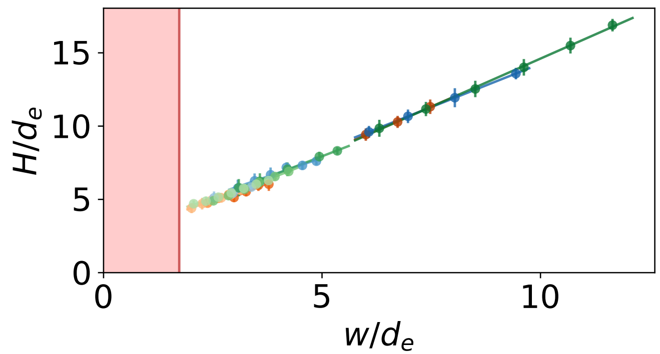
Droplet Shape



Bundle Effective Diameter



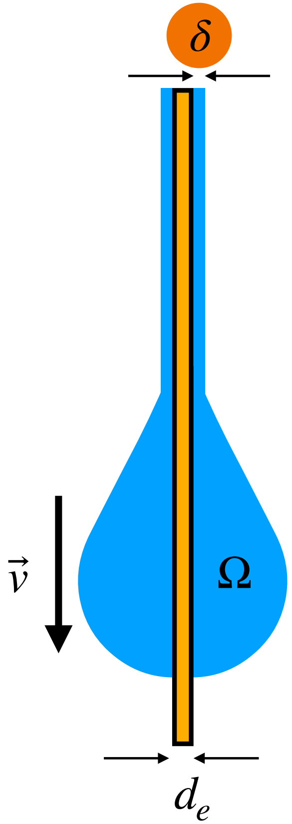


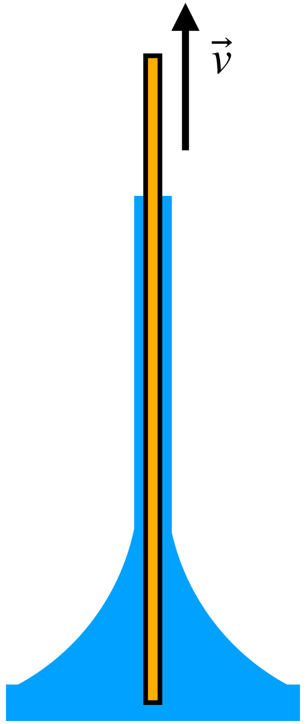


$$\frac{w}{d_e} > \sqrt{3}$$

Fibre substructure does not affect droplet shape

Film thickness





Landau Levich

$$\delta \propto \mathrm{Ca}^{2/3} = \left(\eta v/\gamma\right)^{2/3}$$

- Mass conservation

$$\dot{\Omega} = -\pi d_e \delta v$$

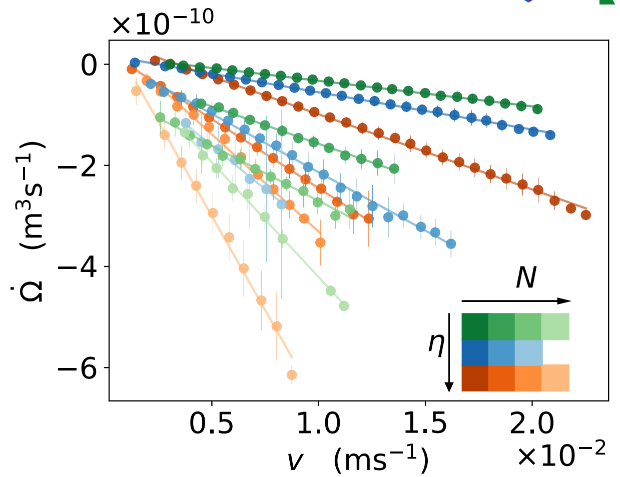
$$\hookrightarrow LL \Rightarrow \dot{\Omega} \propto -v^{5/3}$$

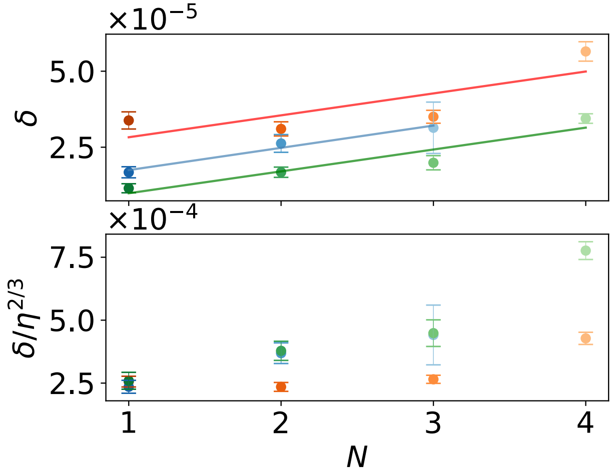
- Film thickness

$$\delta = -\frac{\dot{\Omega}}{v}\frac{1}{\pi d_e}$$

$$\hookrightarrow LL : \delta \propto \eta^{2/3}$$

$$\frac{\delta}{\eta^{2/3}} = -\frac{\dot{\Omega}}{v}\frac{1}{\pi d_e \eta^{2/3}}$$





Fibre substructure leads to thicker liquid film

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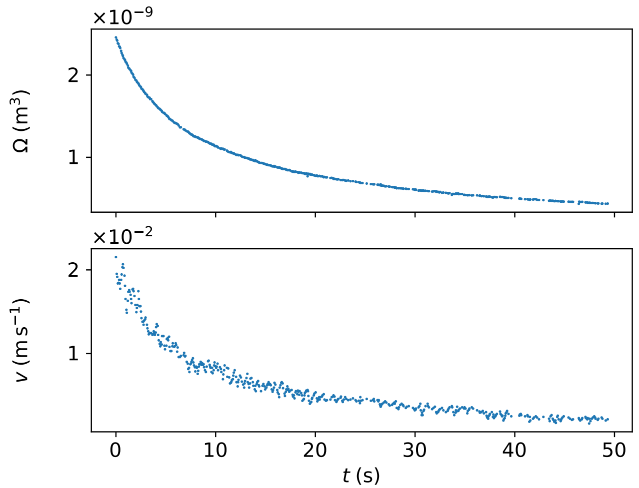
Droplet Speed



$$\sum F = ma_z$$

$$W - F_\gamma - F_\eta = \rho \Omega \ddot{z}$$

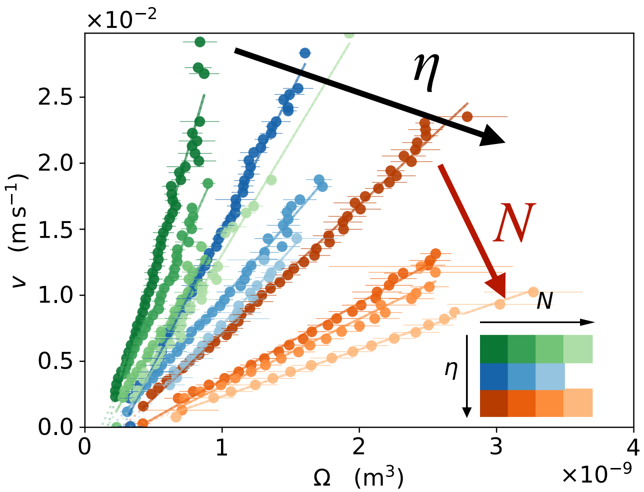
$$\rho g \Omega - \pi \delta \gamma - \eta d_e \xi \dot{z} = \rho \Omega \ddot{z}$$

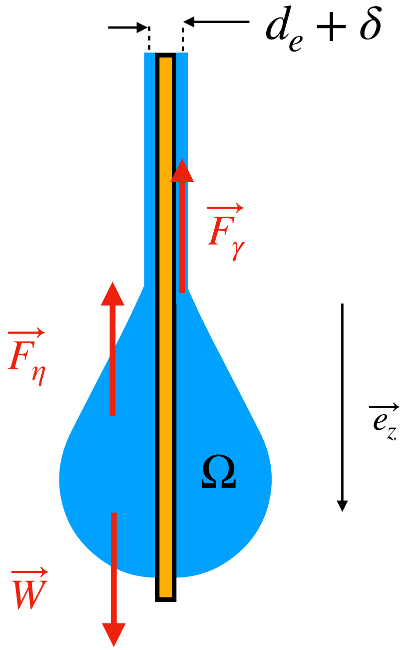
Dissipation factor

Neglecting inertia $(\mathrm{We} \sim 10^{-6})$
and writing $\dot{z} \to v$

$$v = \frac{\rho g}{\xi d_e \eta}\Omega - \frac{\pi \gamma \delta}{\xi \eta}$$

$$\Omega_0 = \frac{\pi \delta \gamma}{\rho g} \approx 0.1 \mu L$$





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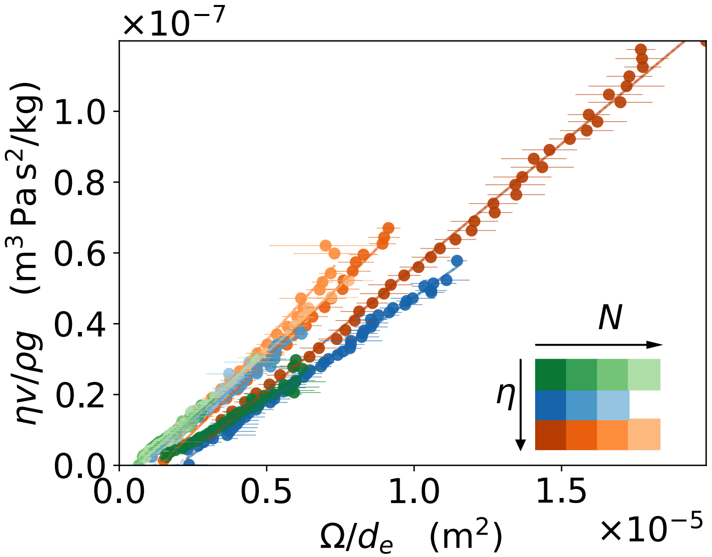
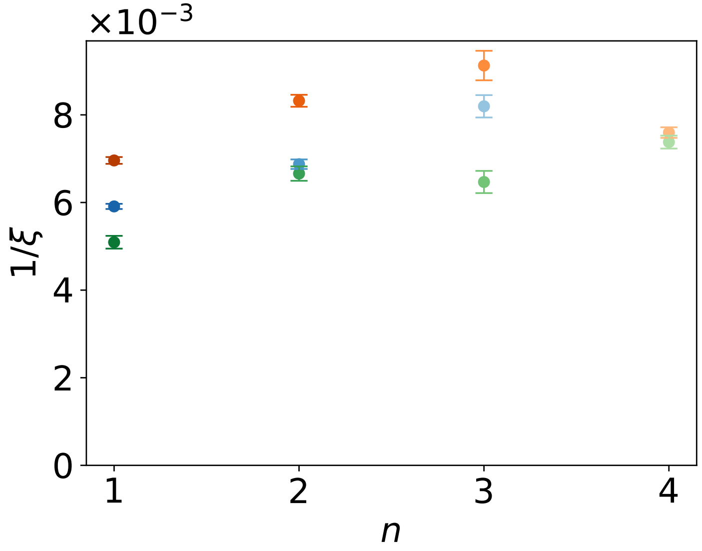
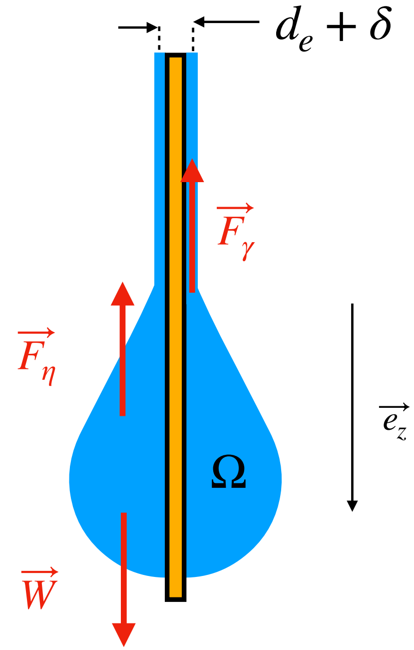
Droplet Speed



$$\left(\frac{v\eta}{\rho g}\right) = \frac{1}{\xi}\left(\frac{\Omega}{d_e}\right) - \frac{\gamma\pi}{\xi\rho}$$



For $n = 1$, $\eta = \text{constant}$ and $d \neq$
$\Rightarrow$ Collapse



Fibre substructure decreases dissipation factor

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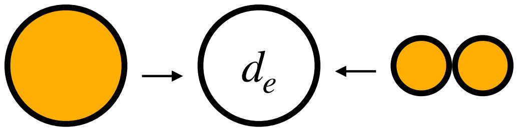
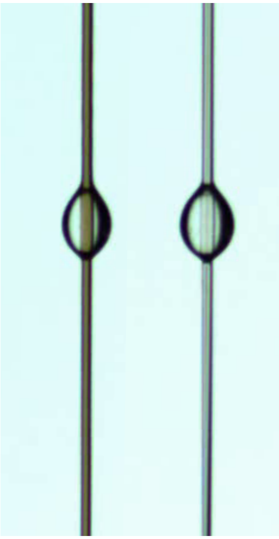
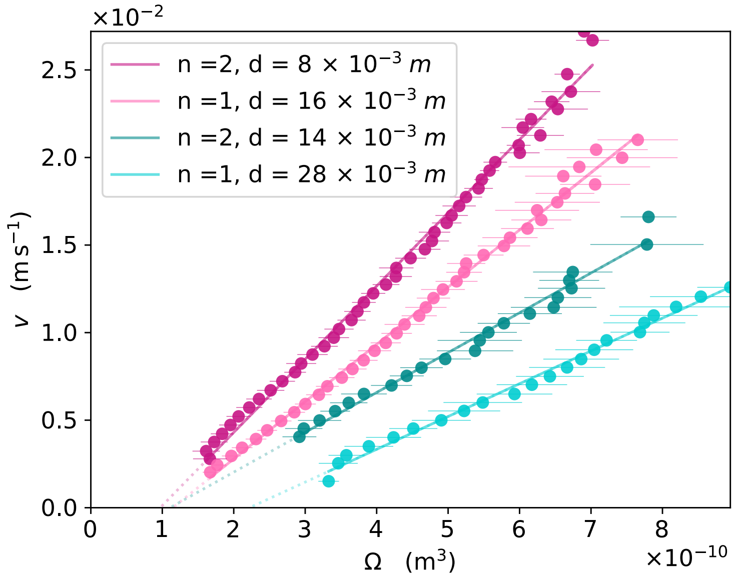
Truth Test

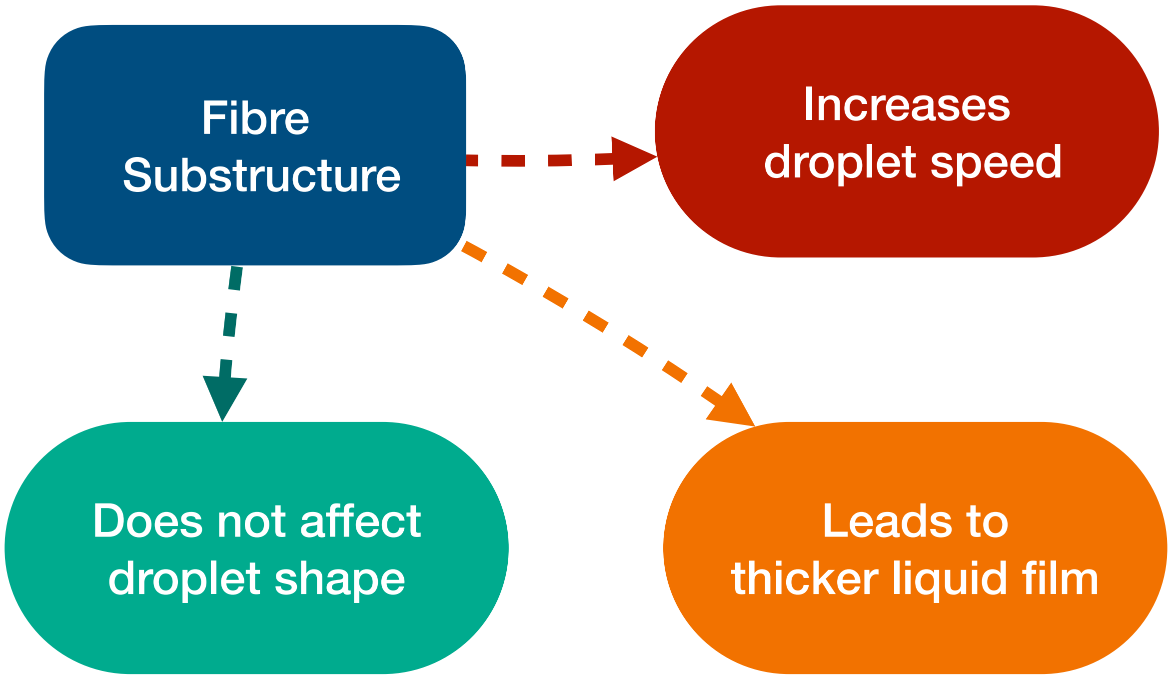






Fibre substructure increases droplet speed

Conclusion



Low cost manufacturing

Increases collection time

Improves subsequent drops dynamics