

Dynamic Porosity of Cementitious Materials Measured with GARField MRI

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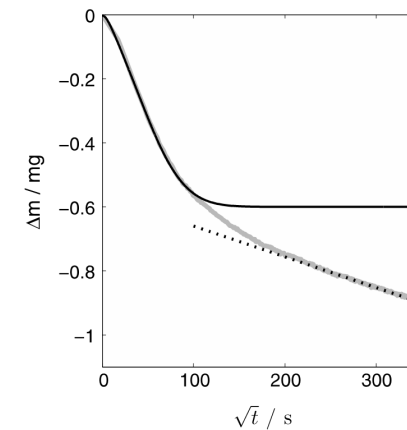
Vanessa Kocaba

PhD student:

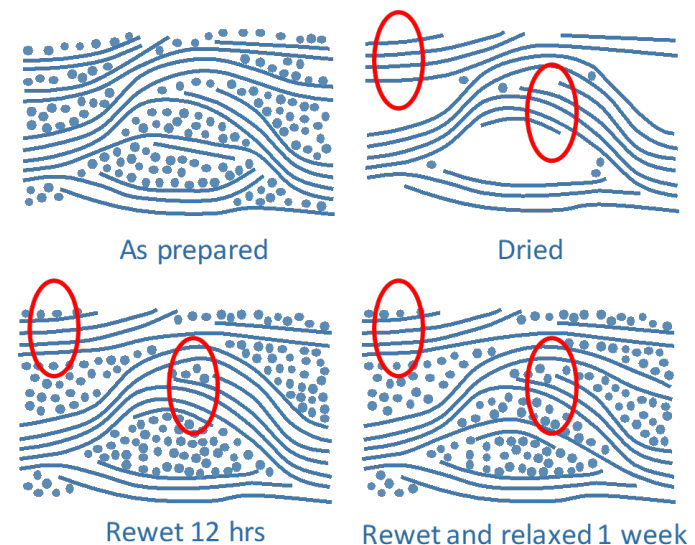
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- Moisture transport in cement is anomalous
 - does not evolve with $t^{0.5}$.
- Time-dependent cement microstructure has been observed in de/sorption experiments
- Aim
 - to better understand links between sorption, microstructure and transport using high resolution GARField MRI.
- Output
 - is a new transport model with a time-dependent transport coefficient.

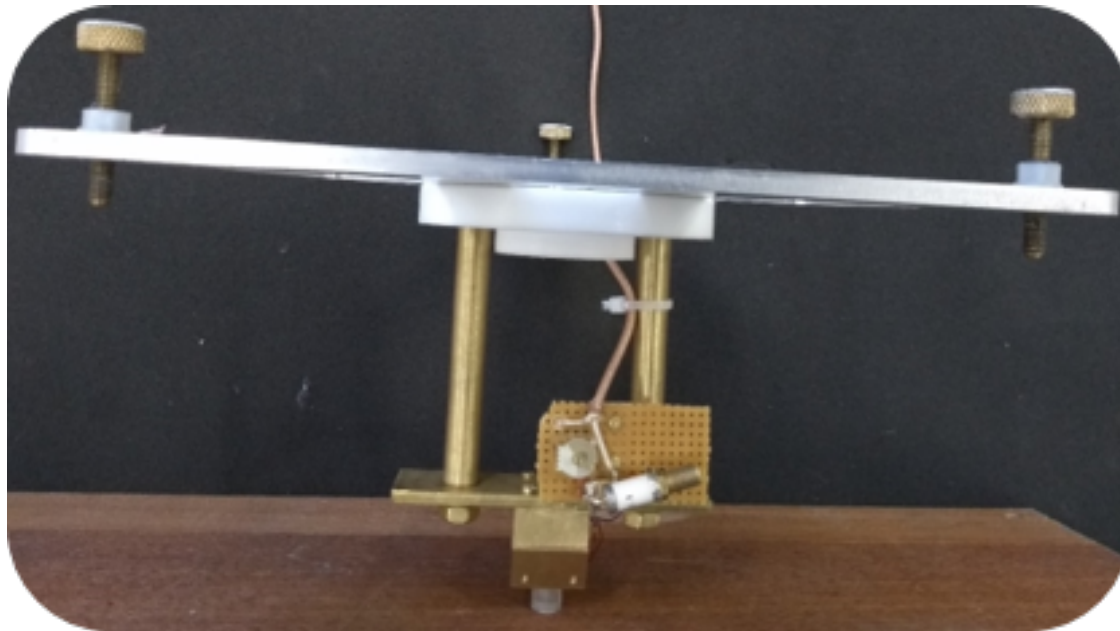


Saeidpour and Wadso, CCR, 70 (2015) 60-66

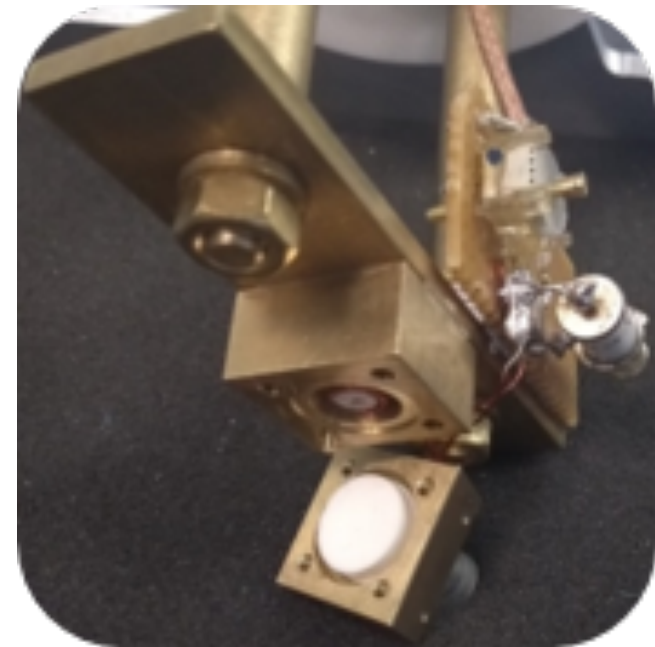


Gajewicz, Gartner *et al*, CCR 2016.

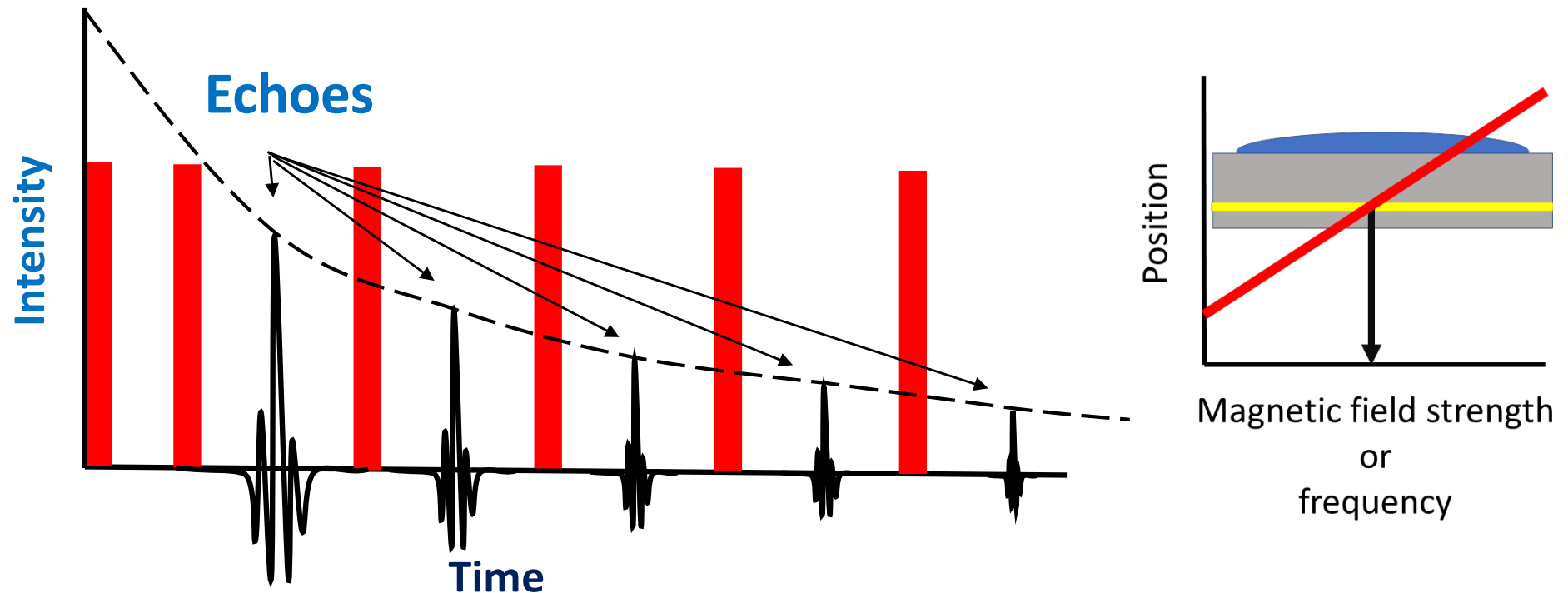
Building NMR probe



Probe with kinematic design



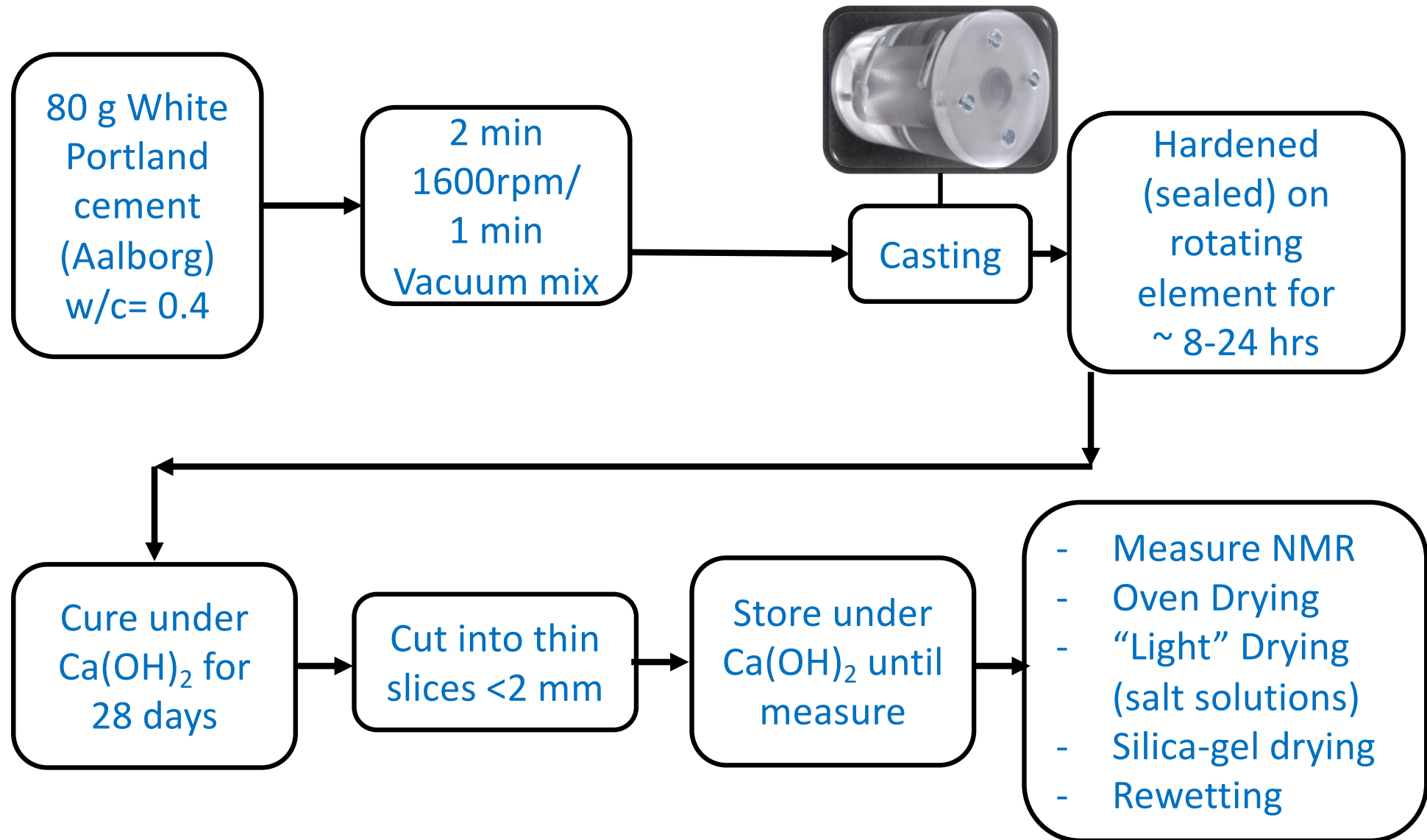
Probe opened up with rubber sample



Intensity → Amount of water

Decay rate → Pore size

Signal frequency → depth below sample surface



A new transport model

Capillary Action:

$$J = -S \frac{\partial c}{\partial x}$$

Diffusion:

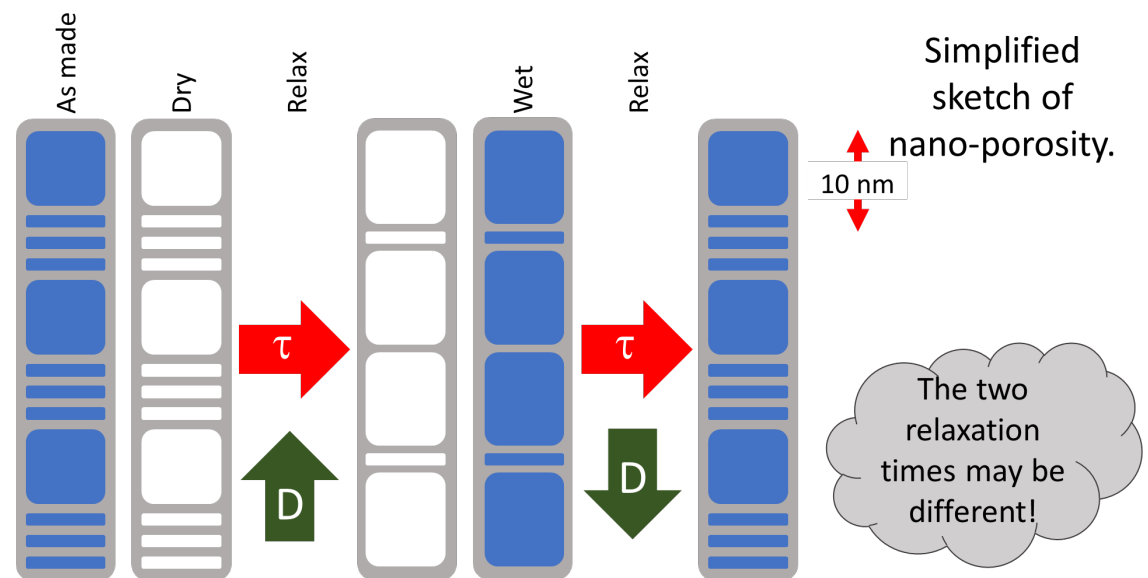
$$J = -D \frac{\partial c}{\partial x}$$

Transport equation with time-dependent transport coefficient:

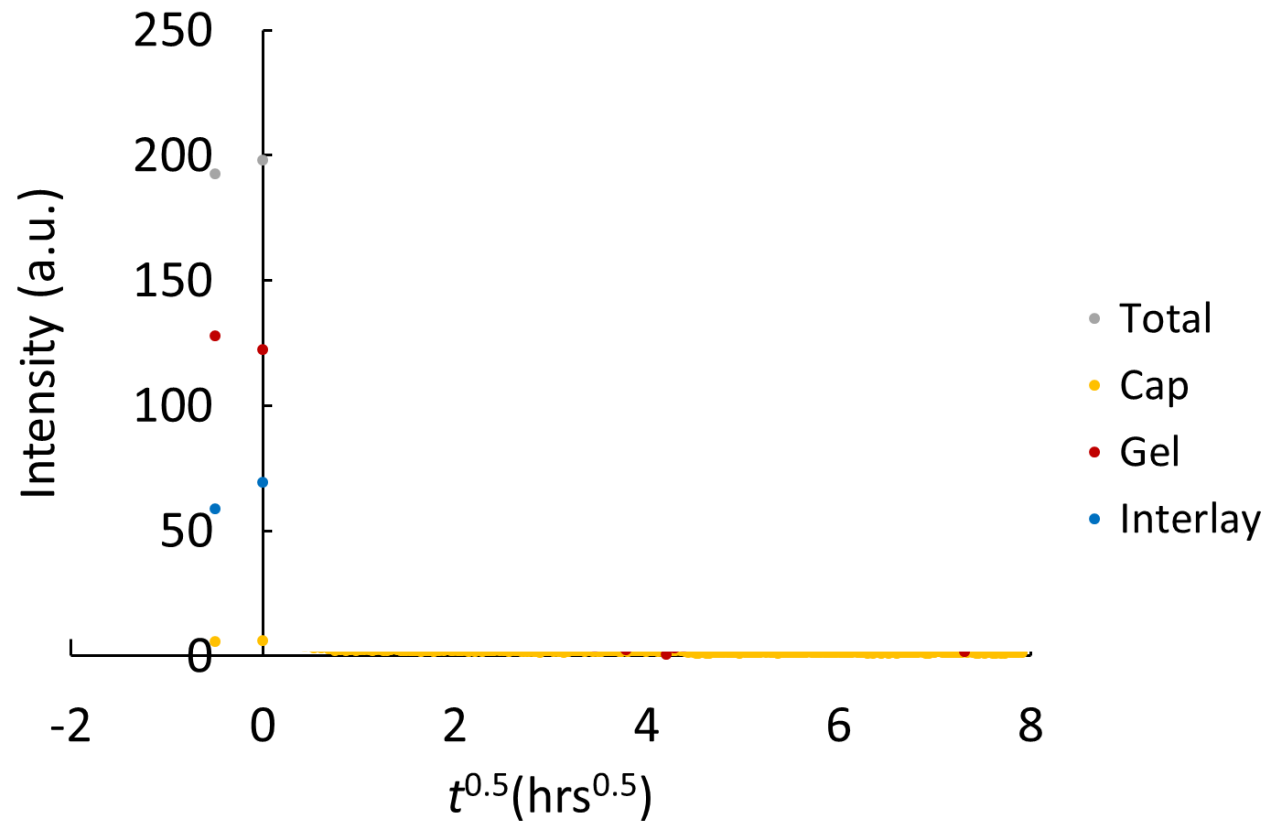
$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x} \left(D(\phi) \frac{\partial c}{\partial x} \right) \quad \frac{1}{D(\phi)} = \sum \frac{\phi_i}{D_i}$$

Pore relaxation rate, with time constant, τ :

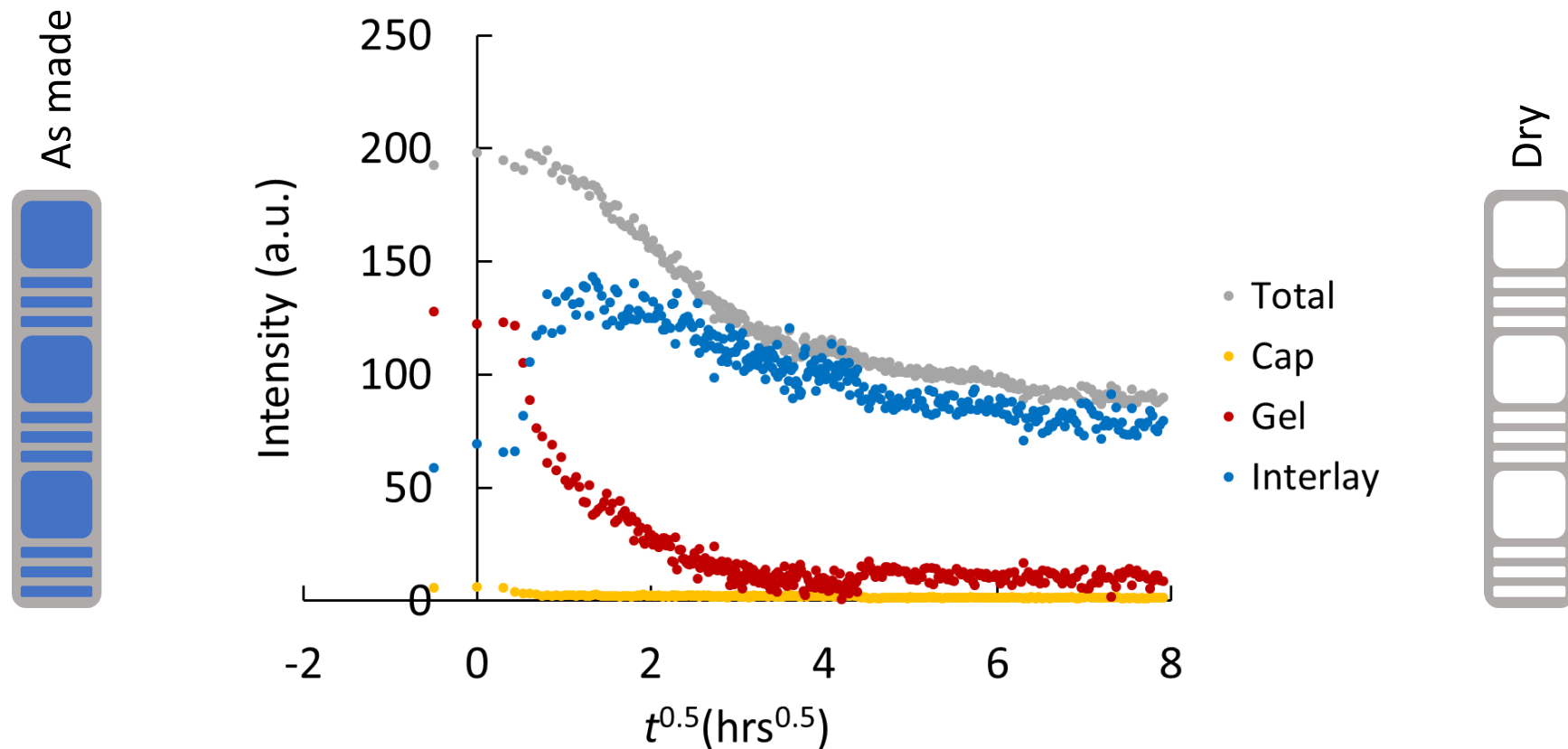
$$\frac{\partial \phi_i}{\partial t} = \frac{\phi_i^0 - \phi_i}{\tau} \quad \phi_{il} = 1 - \phi_{gel} - \phi_{cap}$$



1st De-sorption cycle, drying to <10% RH at a depth of 600 μm :

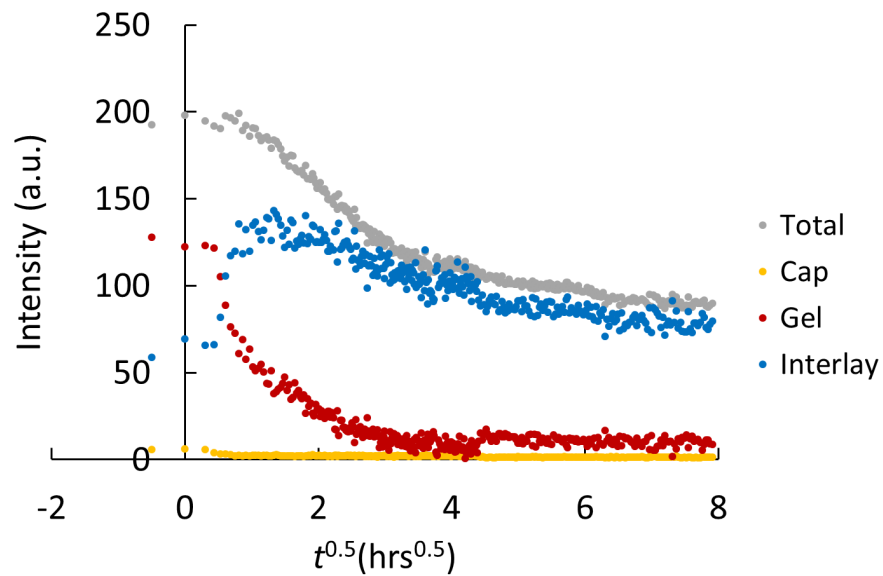


1st De-sorption cycle, drying to <10% RH at a depth of 600 μm :

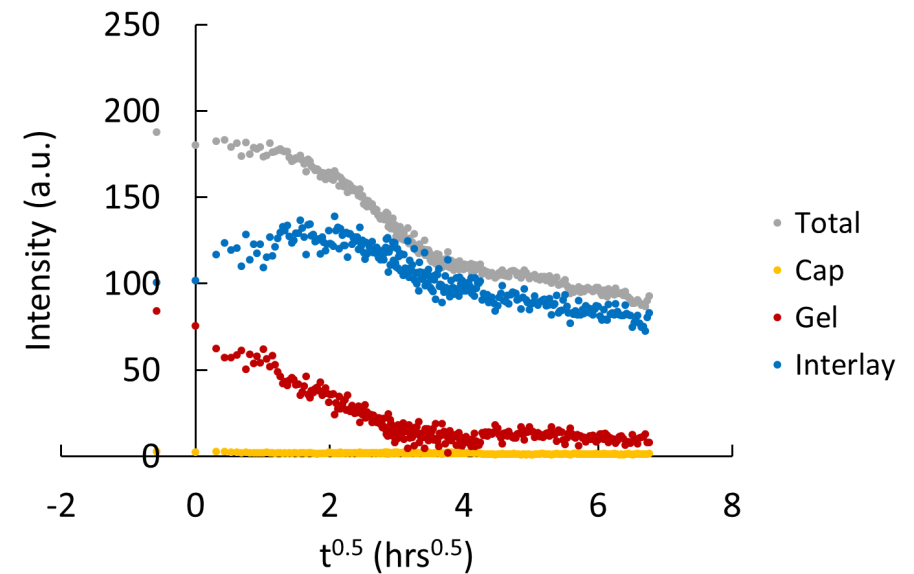


Is it reproducible?

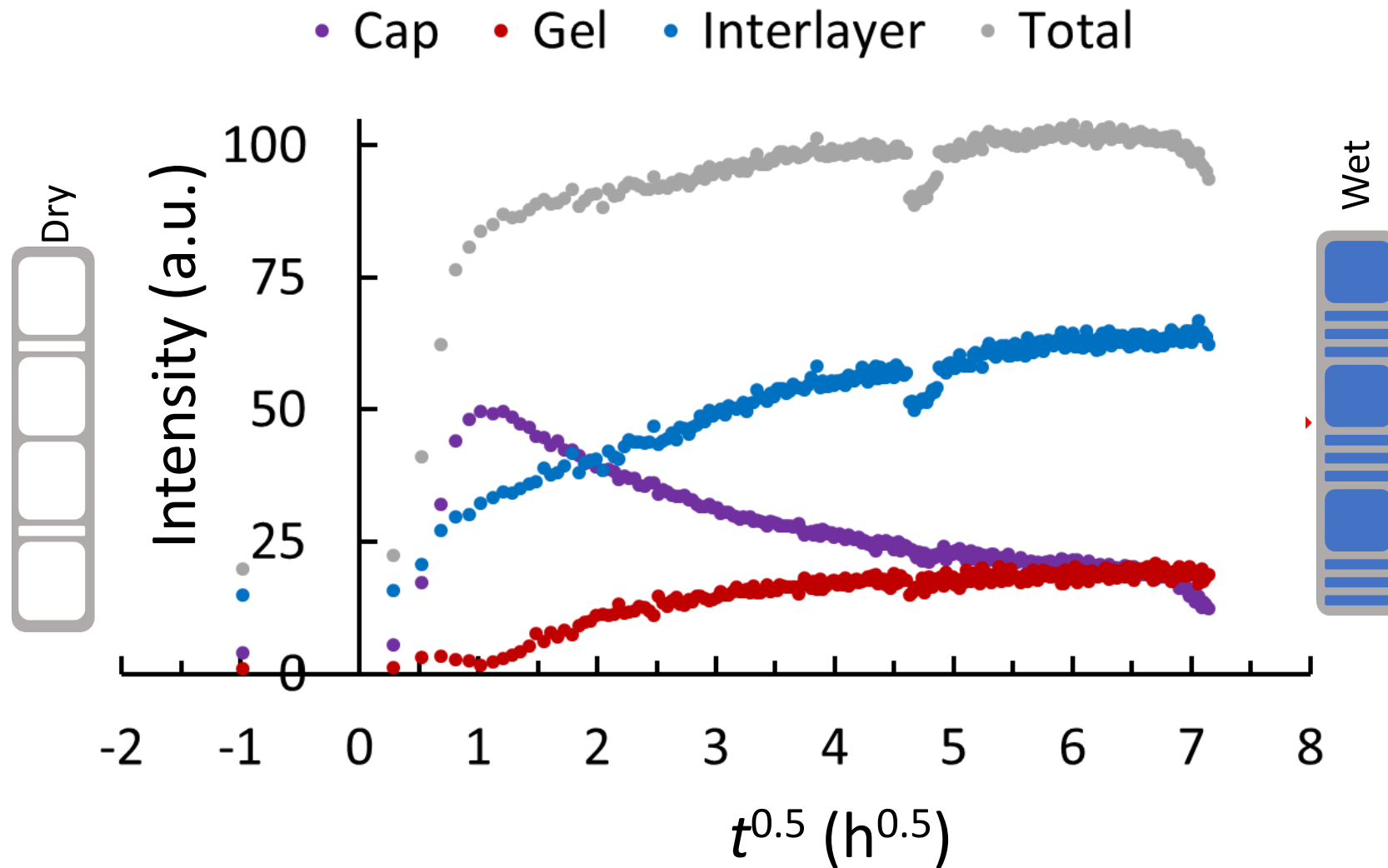
Sample 1



Sample 2

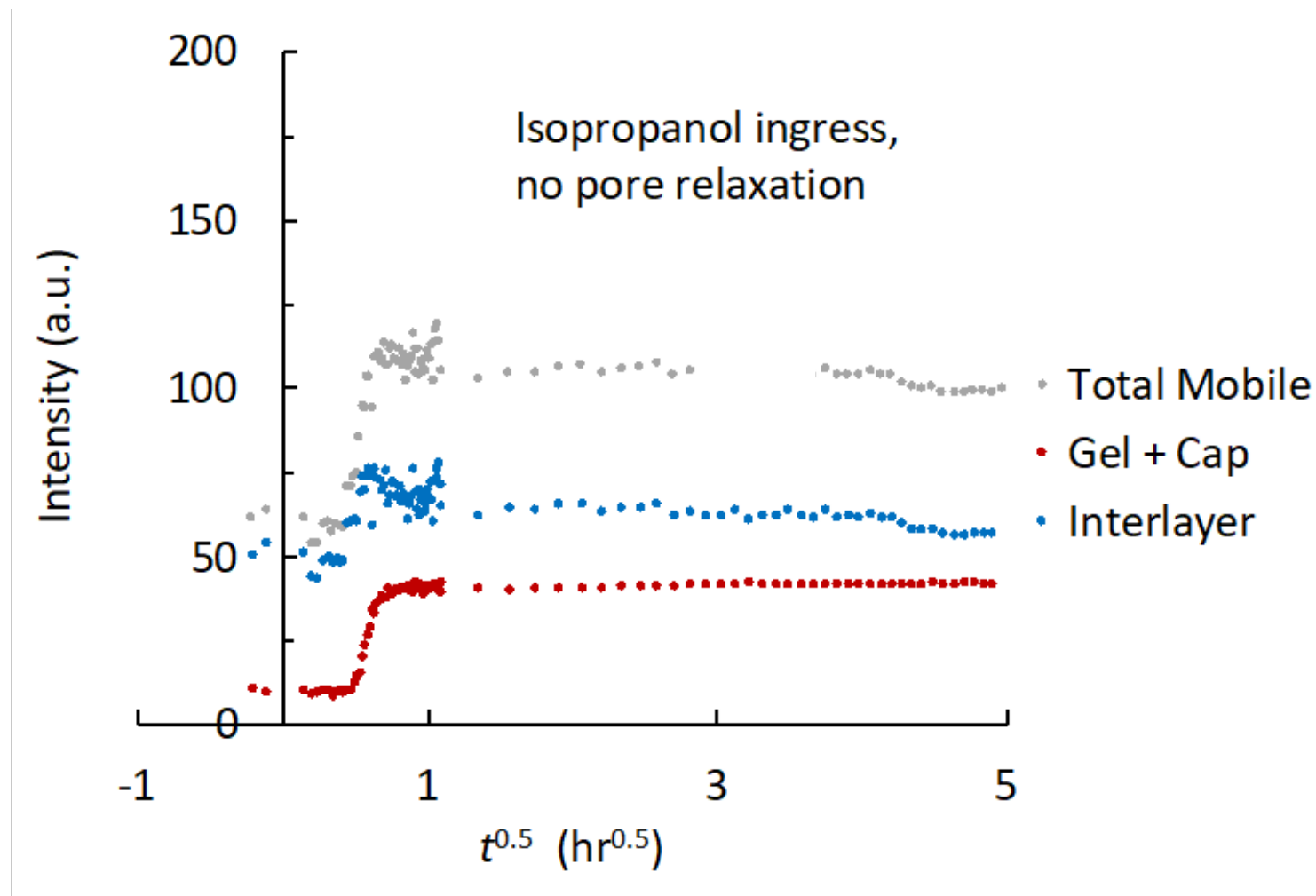


3rd wetting cycle at 600 μm :



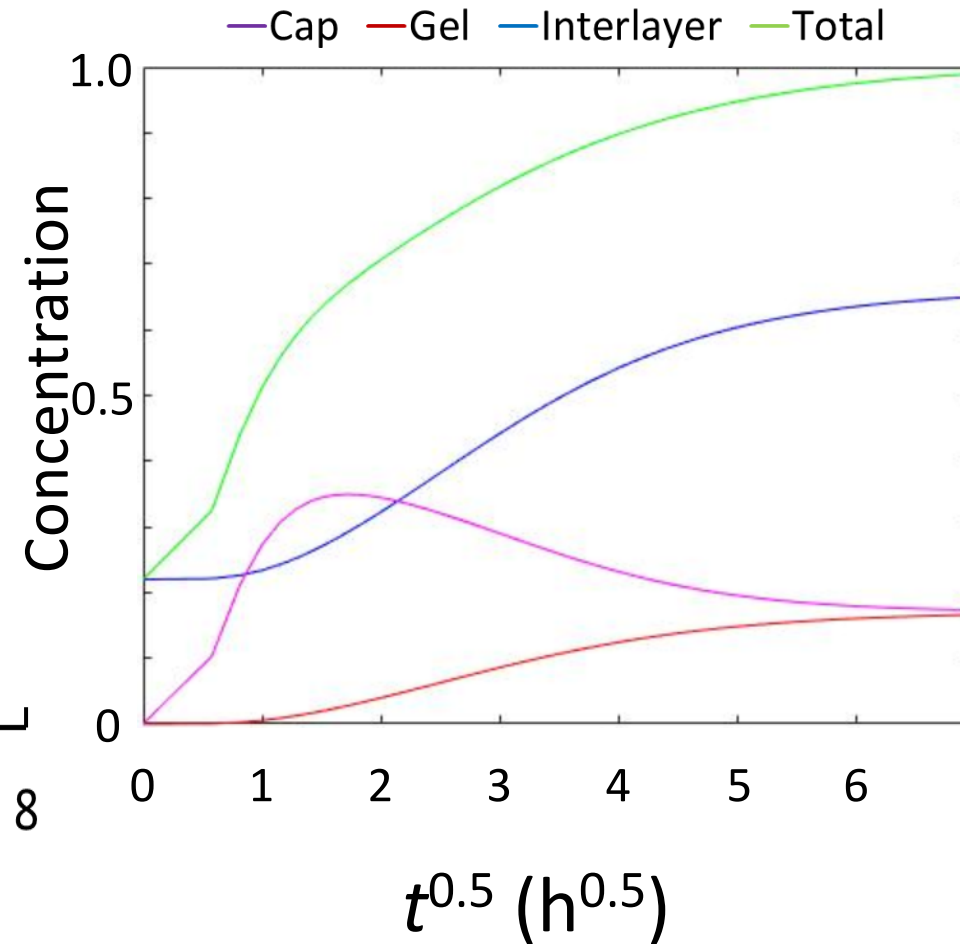
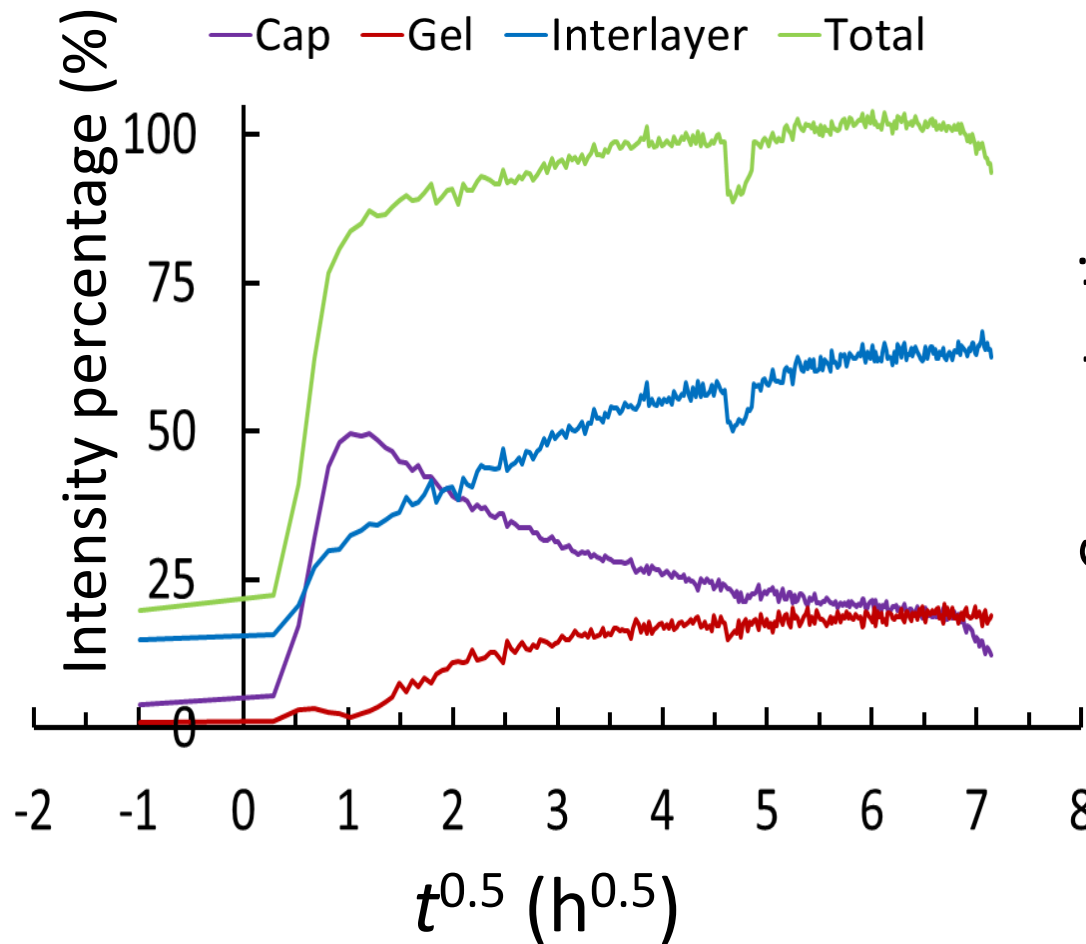
Is it in an artefact?

Ingress of an organic solvent



How does the model work?

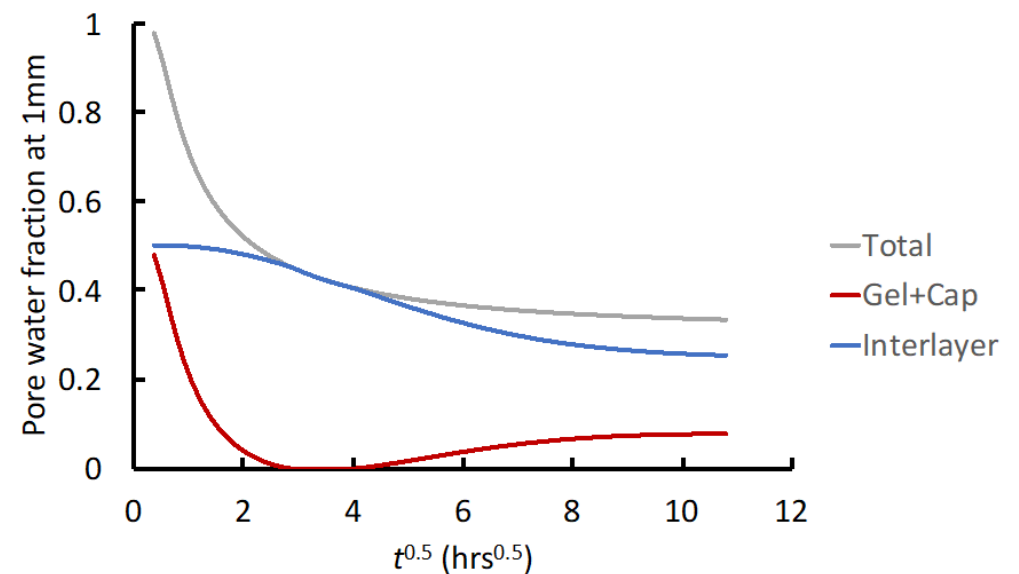
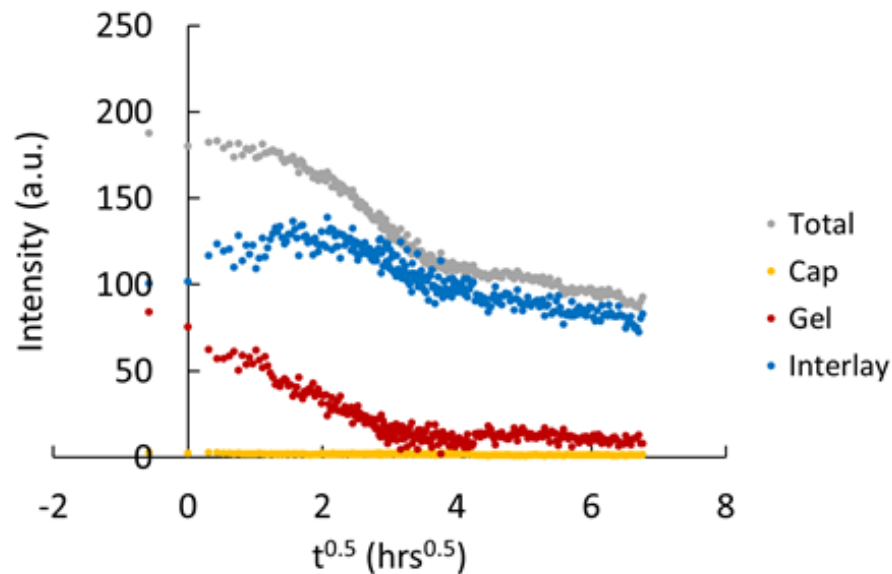
Model simulation of wetting:



How does the model work?

Model simulation of drying:

Very preliminary analysis using an earlier (2 component) version of the model



- **Probe successfully commissioned**
- **De/sorption experiments show time-dependent microstructure**
- **Ingress of organic solvent shows Fickian transport**
- **Keeping a constant water supply needs a solution for ingress experiments**
- **Drying experiments are reproducible**
- **Model data captures the time-dependent changes of the microstructure**
- **Further experiments are required at different RH for longer timescales**

Secondments /Training:

-University College Dublin – Measure the effect of non-/paramagnetic ions on T_1 relaxivity using Fast Field Cycling NMR (data will be used for ESR 7) (End of October 2019, 1 week)

-MR solutions – Developing new instrumentation - beginning of 2020 (1-2 months)

Outreach:

(26th July 2019) – Joint outreach activity with ESR's 7, 9 and 11 held at USurrey for 16 year old students 1h presentation/ 2h lab work