

# Sparse fibers and complex powder reconstitution

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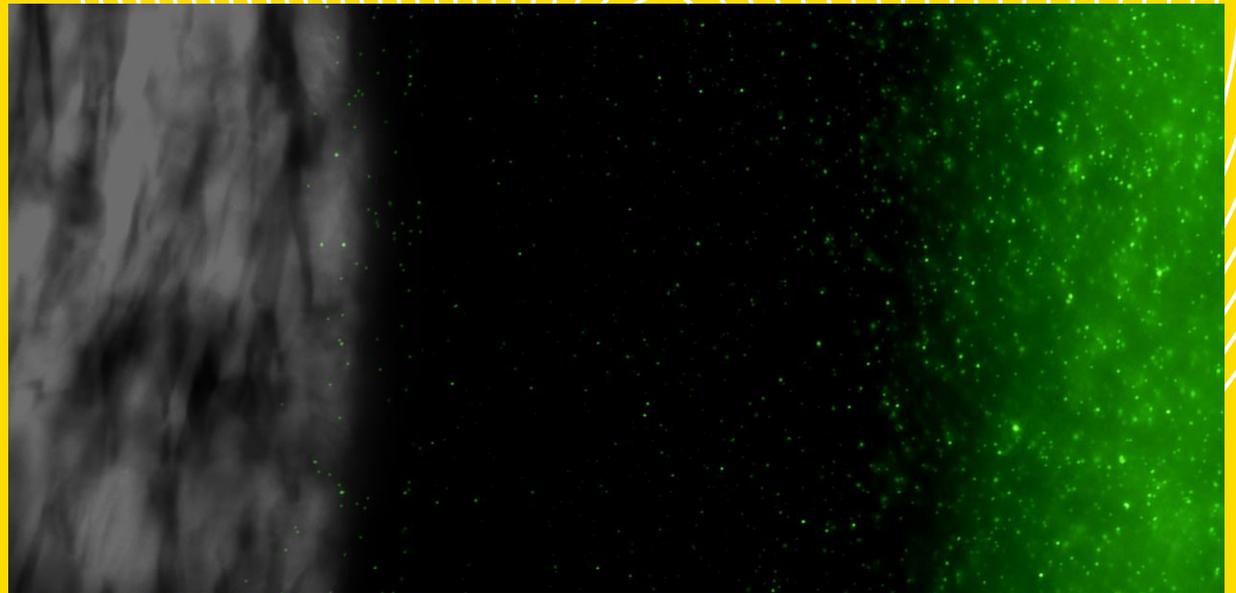


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IFPRI Powder Reconstitution Workshop  
June 13-15, Toronto



**UNSW**  
SYDNEY



# Industry trend in consumer products: reconfiguration and compaction

Our Brands ▾

Our Impact ▾



Our Story ▾

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MARCH 6, 2024

*A decade in the making, Tide evo brings design, convenience and breakthrough innovation together for the ultimate clean*

CINCINNATI--(BUSINESS WIRE)-- Tide, America's #1 trusted laundry detergent brand, is excited to introduce Tide evo at SXSW 2024, marking a leap forward in laundry innovation driven by consumer insights. In an era where convenience and superiority are not just desired but expected, Tide has listened to consumers' voices, shaping the development of Tide evo. This revolutionary laundry tile form emerges as a direct response to the call for a laundry solution that is lighter, faster and simpler. Tide evo represents a new chapter in laundry care, designed to make doing laundry a more efficient and enjoyable experience for consumers, reflecting their preferences for products that align with a modern lifestyle.



At SXSW, Tide evo's debut will begin a new chapter in laundry's evolution, from soap to detergents to powders to liquids to PODS, and now, to fiber tiles – the form of the future. Rooted in addressing consumers' everyday challenges, Tide evo emerges as a step forward in innovation, seamlessly blending a reduction in effort and environmental impact of laundry – continuing Tide's commitment to contribute positively to the planet and deliver superior cleaning.

"Today marks a significant milestone for Tide, as we unveil Tide evo at SXSW 2024, marking a new phase of innovation in laundry care," stated Sundar Raman, Chief Executive Officer, P&G Fabric & Home Care. "Tide evo embodies over a decade of research and development, signifying a major advancement in how we approach cleanliness and efficiency in our daily lives."

Innovative Design for the 21st Century

Tide evo, the culmination of years of extensive research and development, introduces a revolutionary laundry tile form – unlike anything offered in laundry today. This new category

Move from mostly-water products or low bulk density powders to solid “tiles”. Reduces shipping costs and packaging volume.

# Industry trend in consumer products: reconfiguration and compaction

## A P&G First: Shampoo and Conditioning Bars.

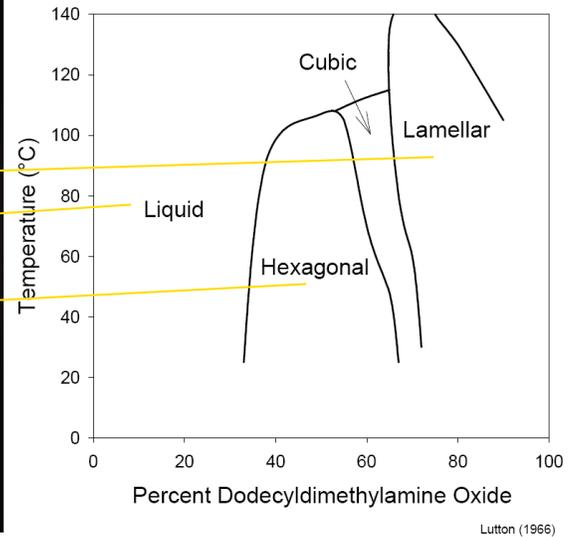
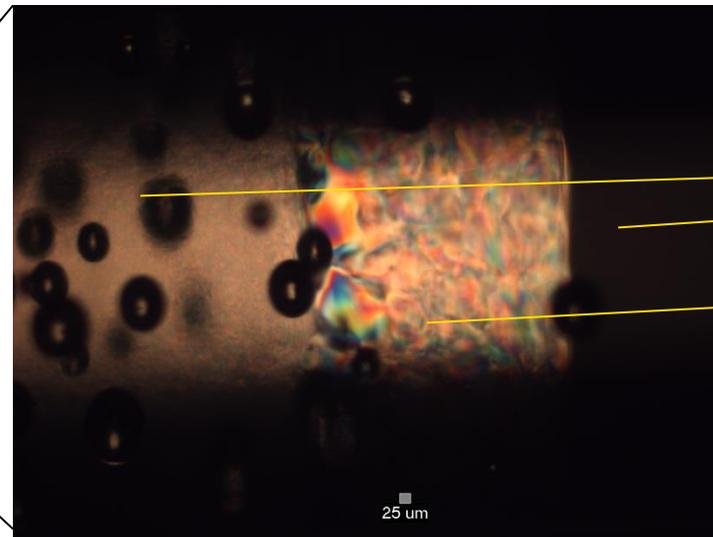
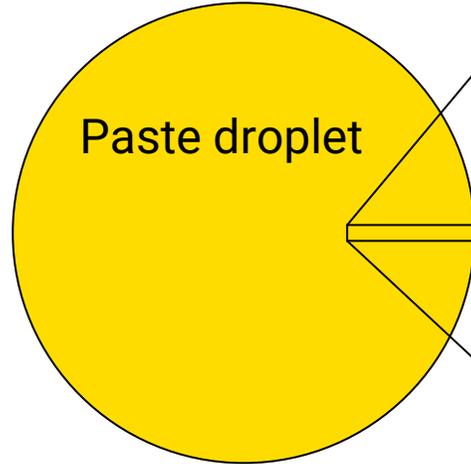
P&G Beauty Team Meets Consumer Demand for Sustainable Products



Reduction in packaging, less need for containment in solid form, avoiding plastic bottles and content. Sustainability claims for consumer.

# Phase behavior as a hydration trajectory

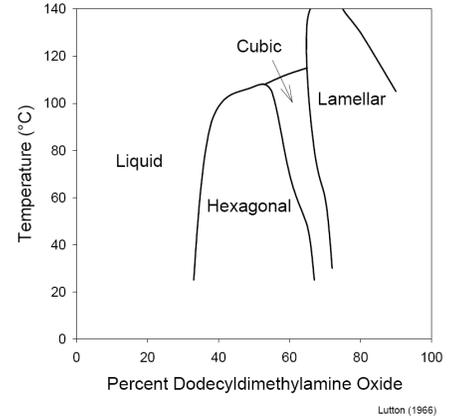
Solvent



C12E6 capillary image

# Rheology of hydrated phases complex and counterintuitive

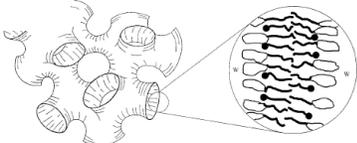
Worms < Sponge < Lamellar < Hexagonal < Cubic



Order upon dilution is counterintuitive

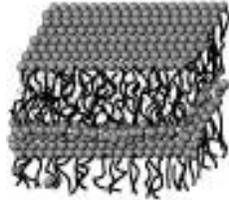


10 Pa-s



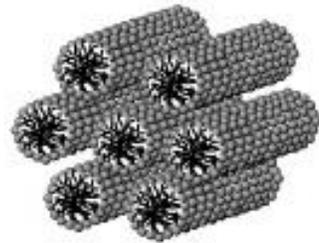
50 Pa-s

$\frac{v}{al} \sim 1$

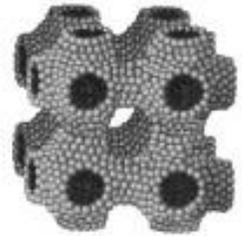
100 Pa-s

$\frac{1}{3} < \frac{v}{al} < \frac{1}{2}$

10,000 Pa-s

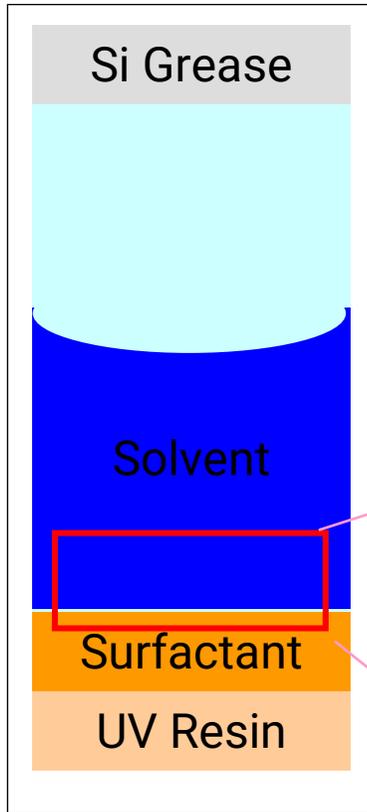
$\frac{v}{al} > 1$

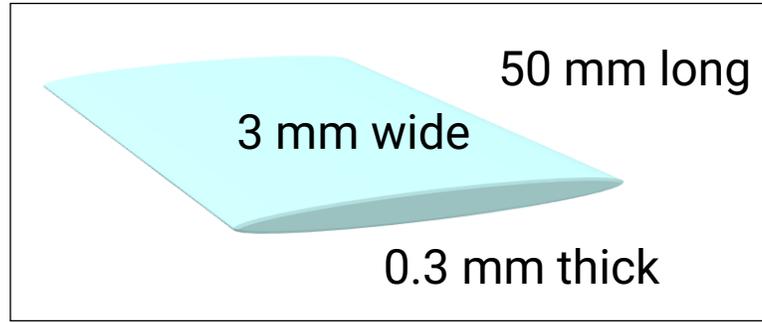
100,000 Pa-s

Even when a powder is soluble, the structures it forms can be a limiting factor in kinetics

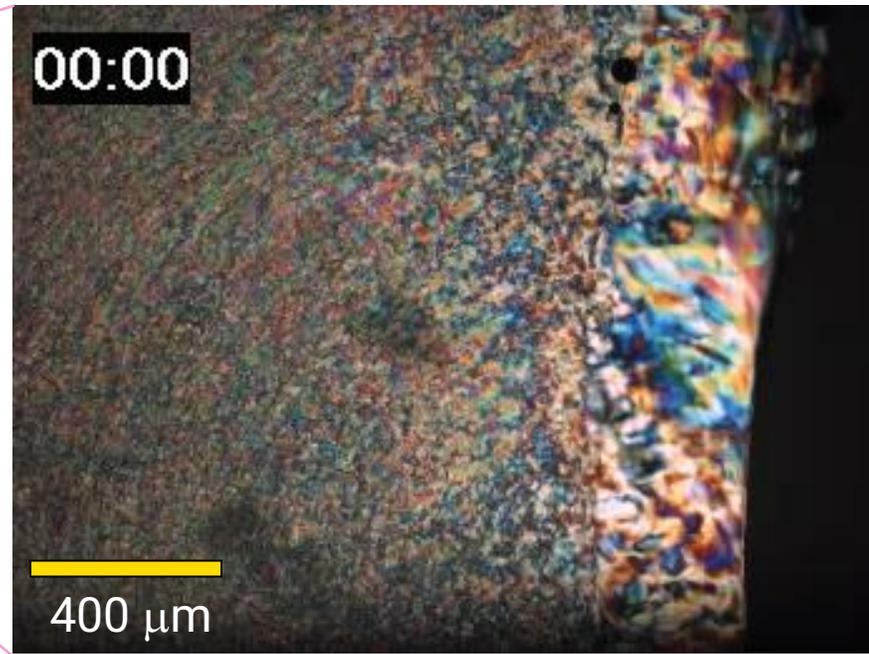
# Characterization of dissolution



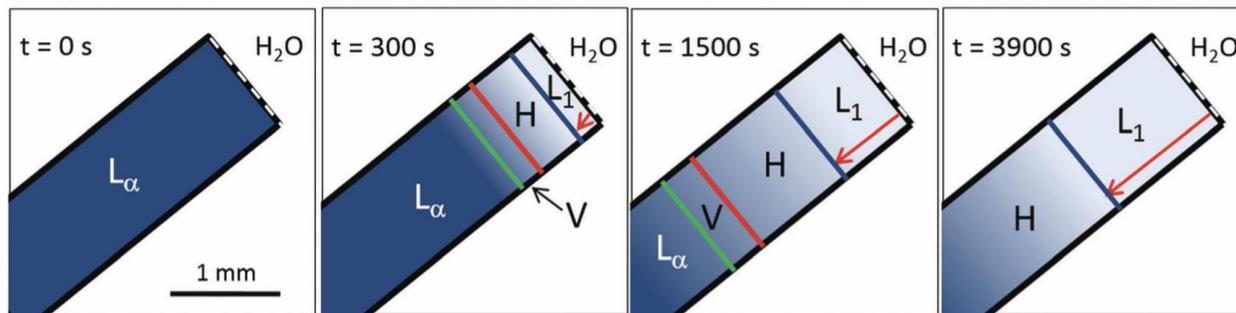
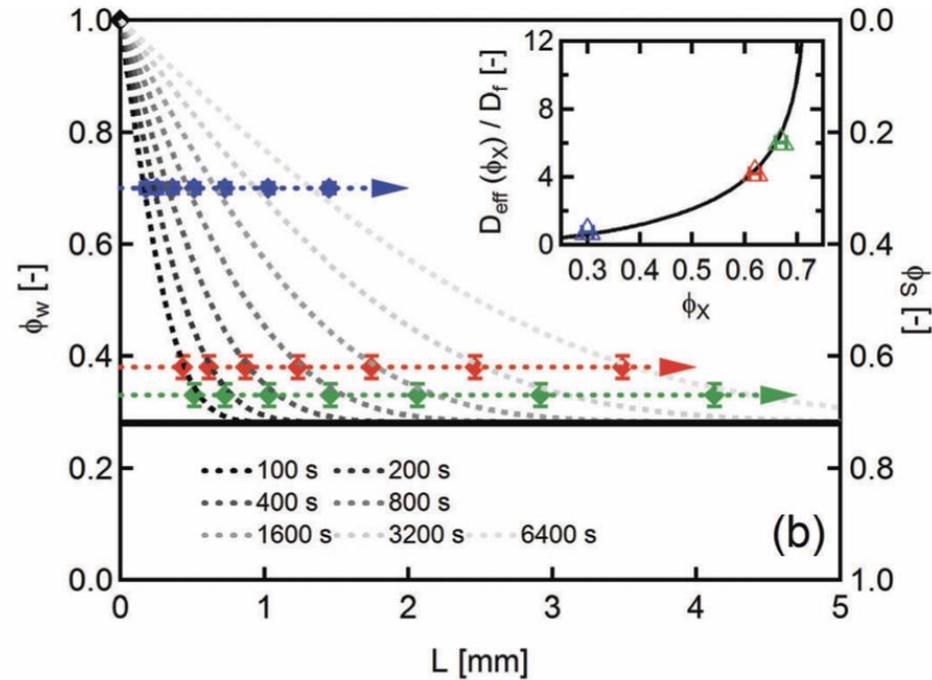
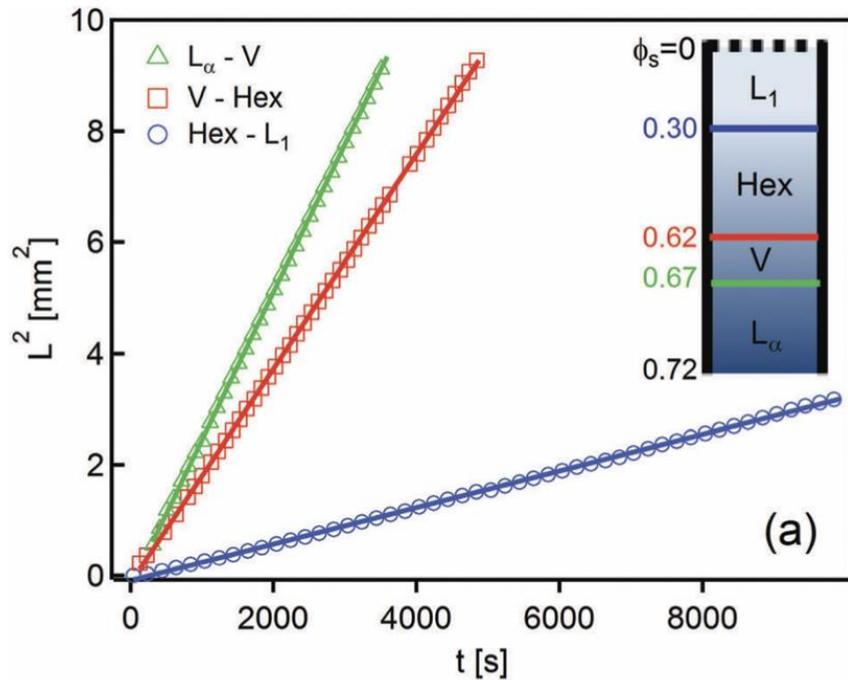
*Top view*



*Corner view*

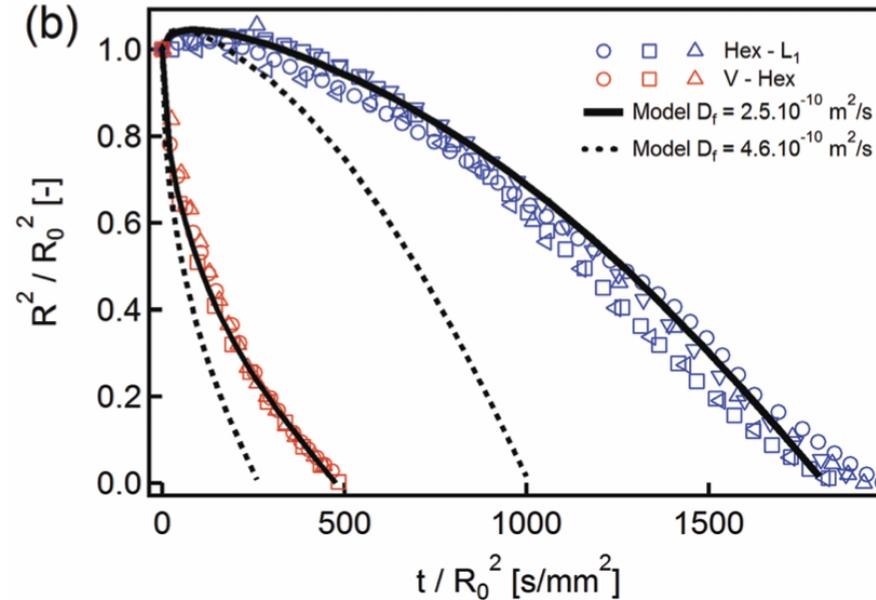
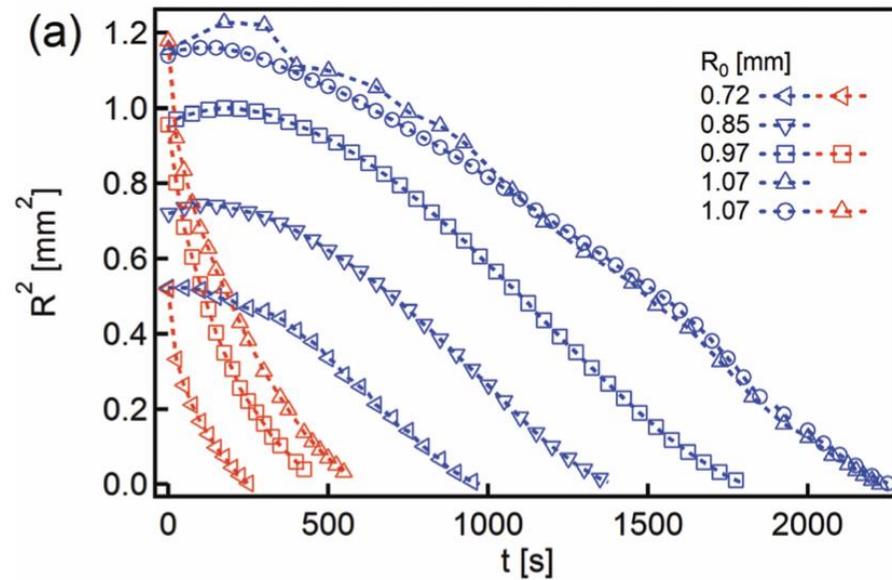
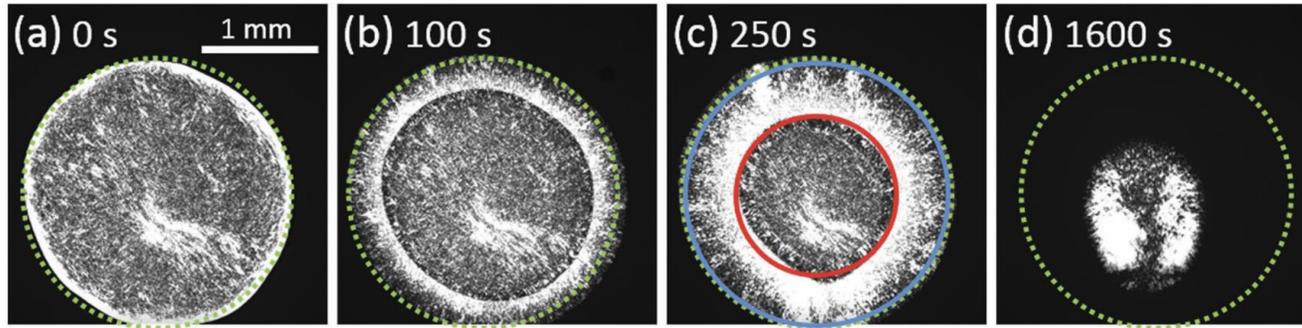


# Measurement of characteristic rates



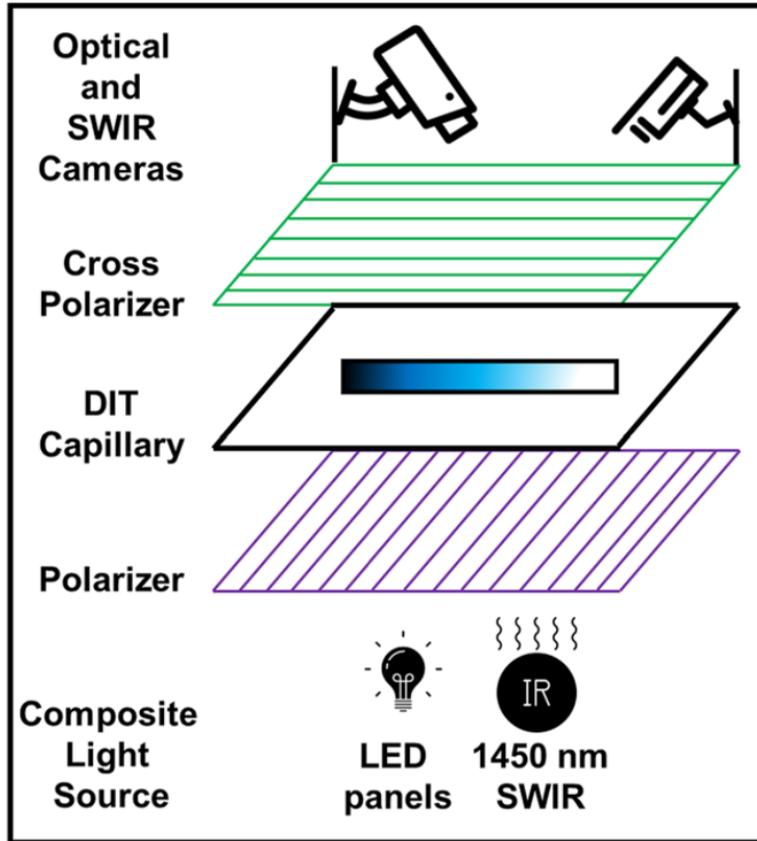
Velocity of interfaces can be used to measure the effective diffusivity in the phases. Rate of dissolution varies with initial surfactant concentration.

# Measurement of characteristic rates

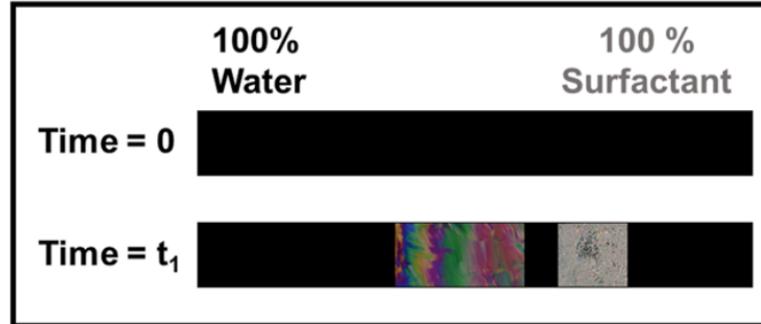


Velocity of interfaces can be used to measure the effective diffusivity in the phases. Rate of dissolution varies with initial surfactant concentration.

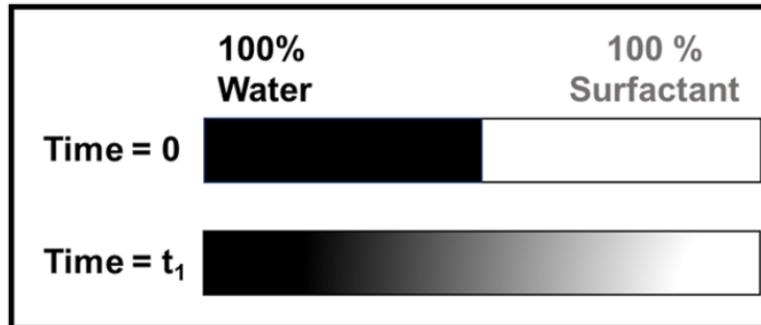
# Quantifying via water level



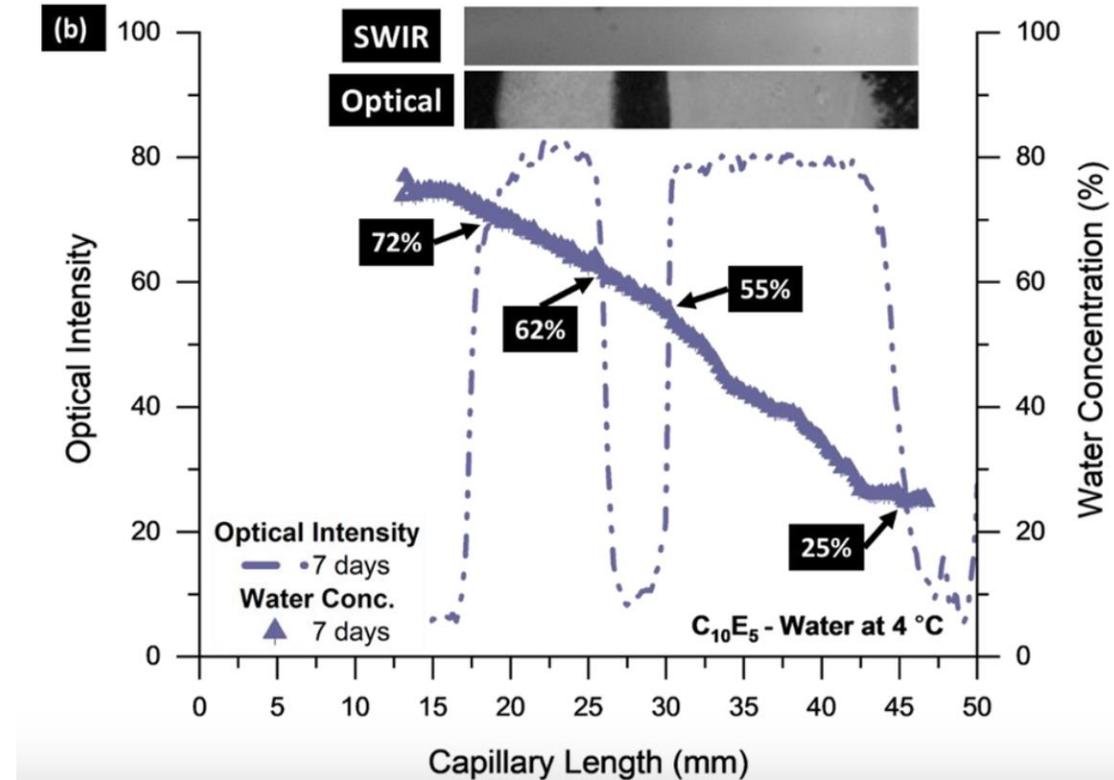
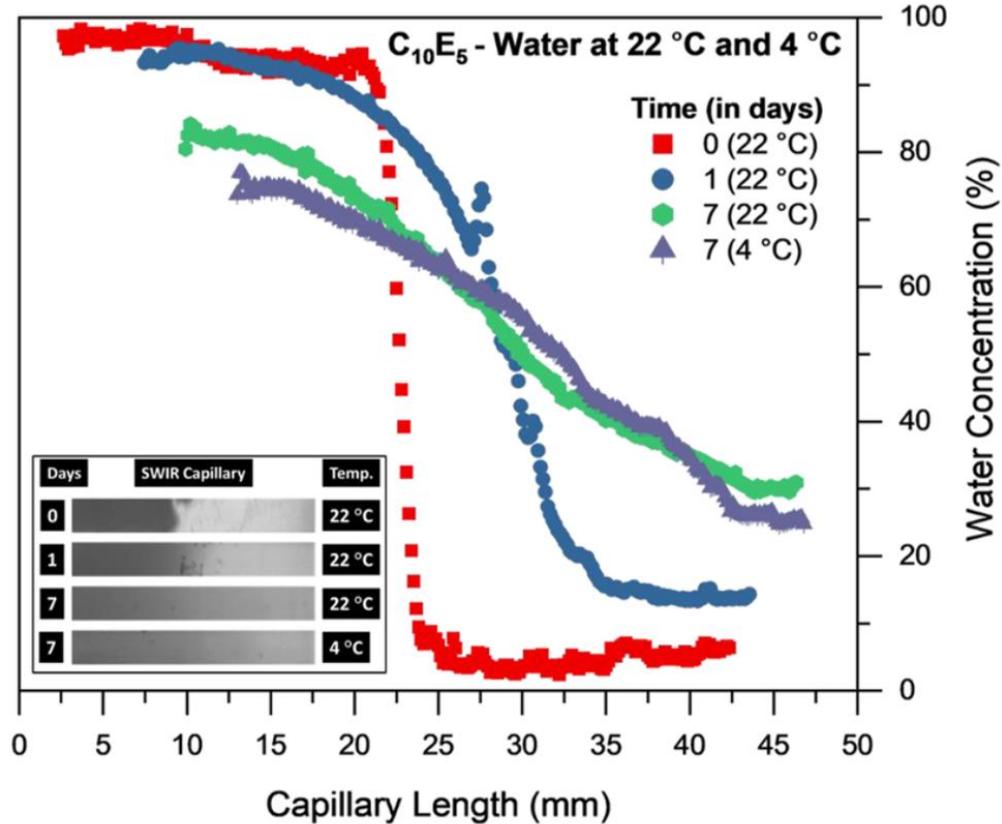
Sample Under Cross Polarized Light (Phase)



Sample Under SWIR (Concentration)

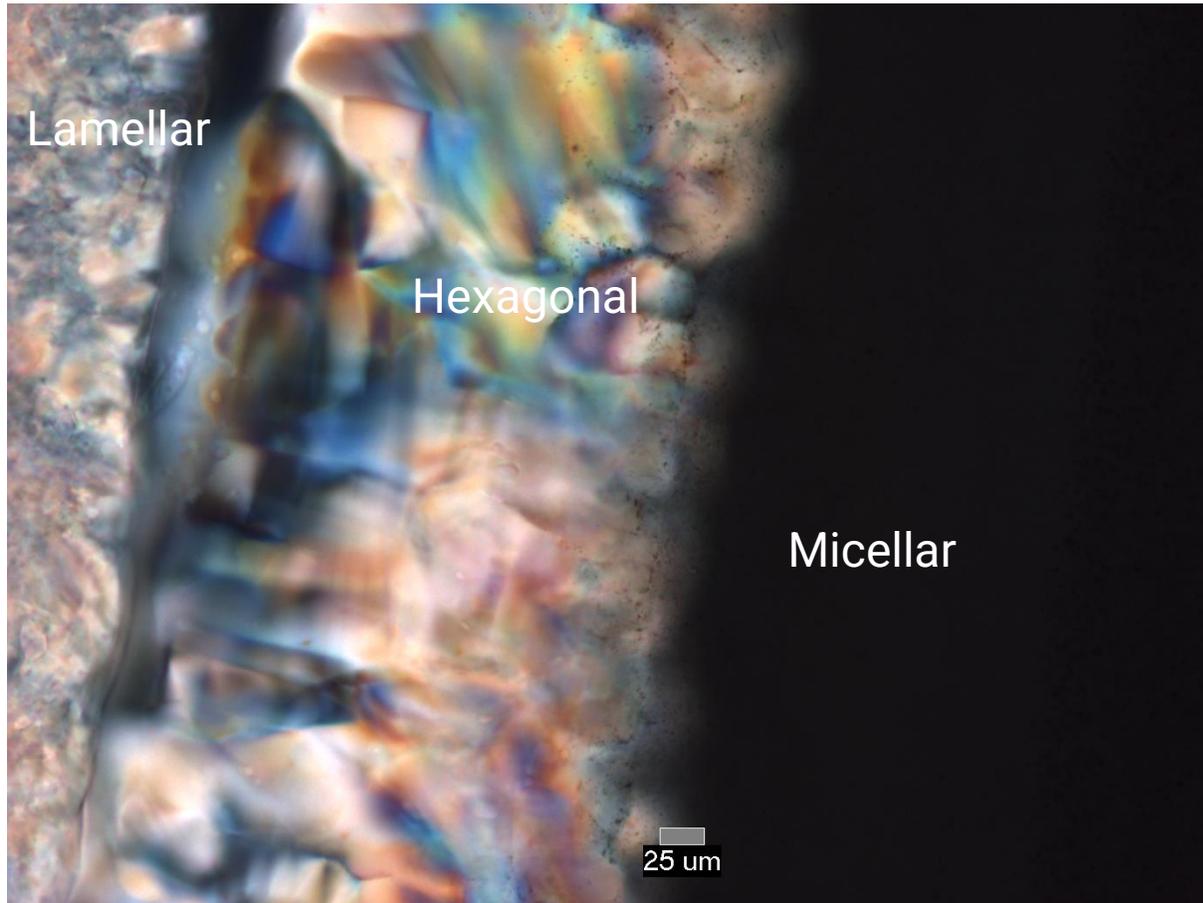


# Quantifying via water level



Kelkar et al., Rev. Sci. Instrum. **95**, 035102 (2024)

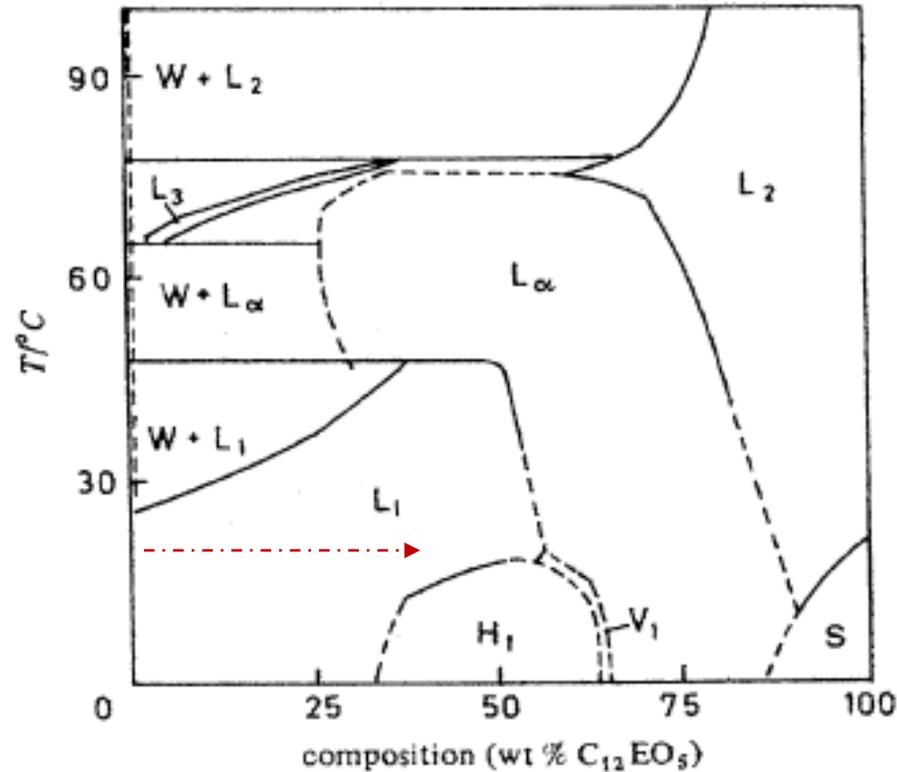
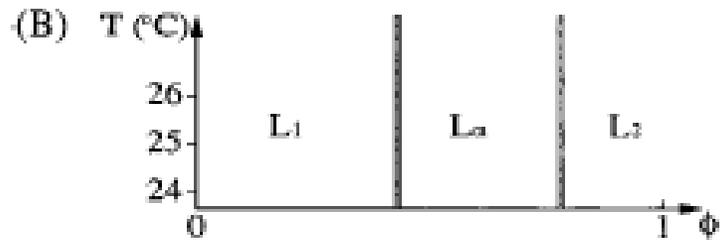
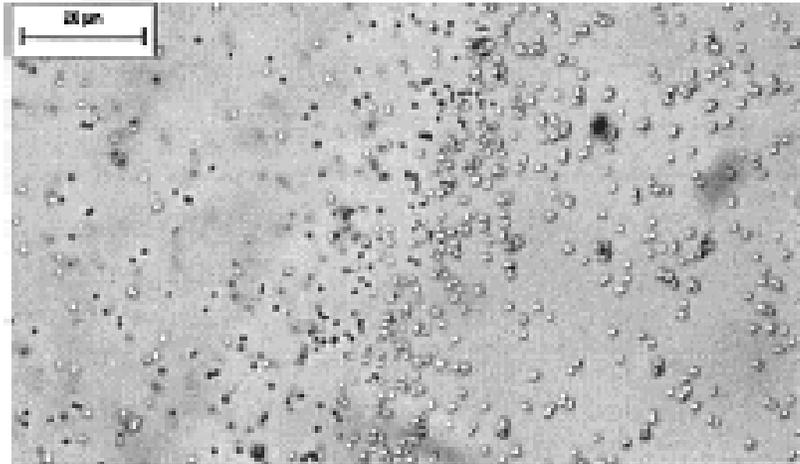
# Morphological variations



Adding colloidal tracers to the system reveals another barrier to dissolution: a very viscous concentrated micelle layer.

Thermodynamically this is treated as one phase: micellar, but has a sharp transition within that region like a separate phase.

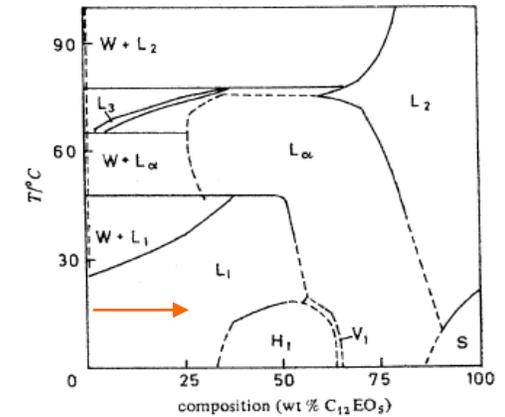
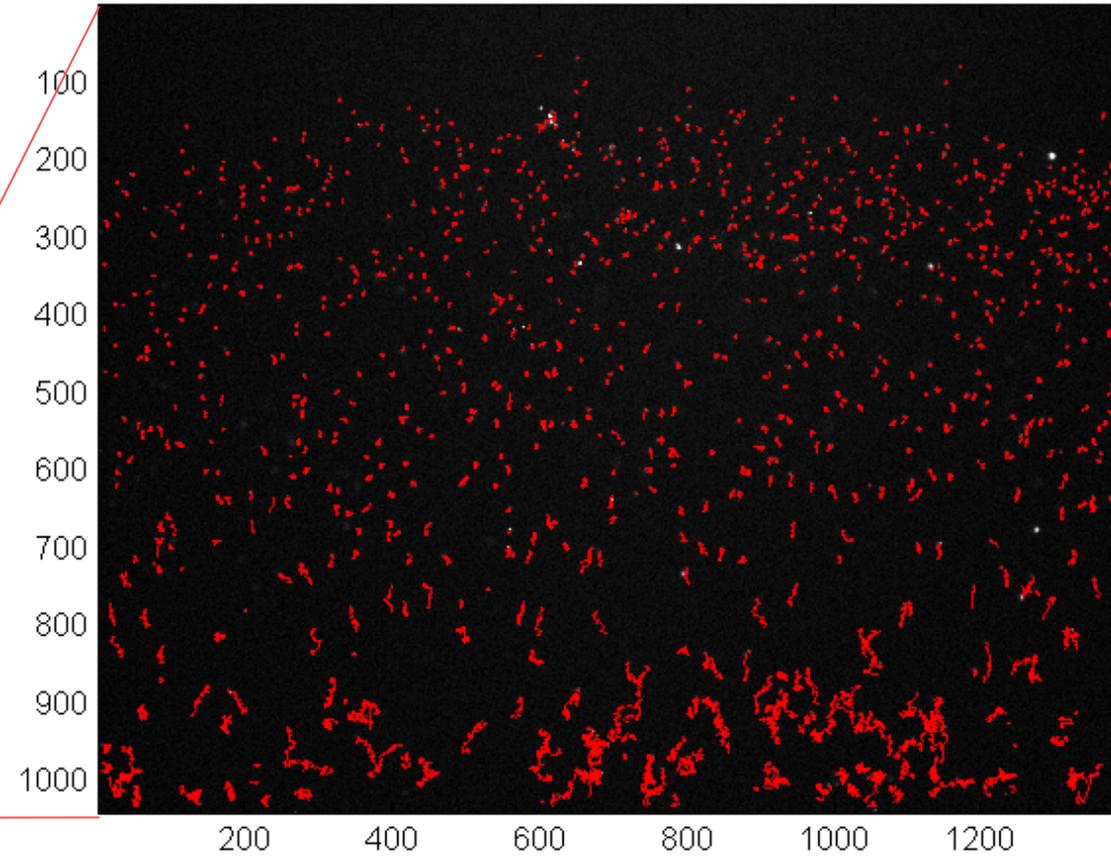
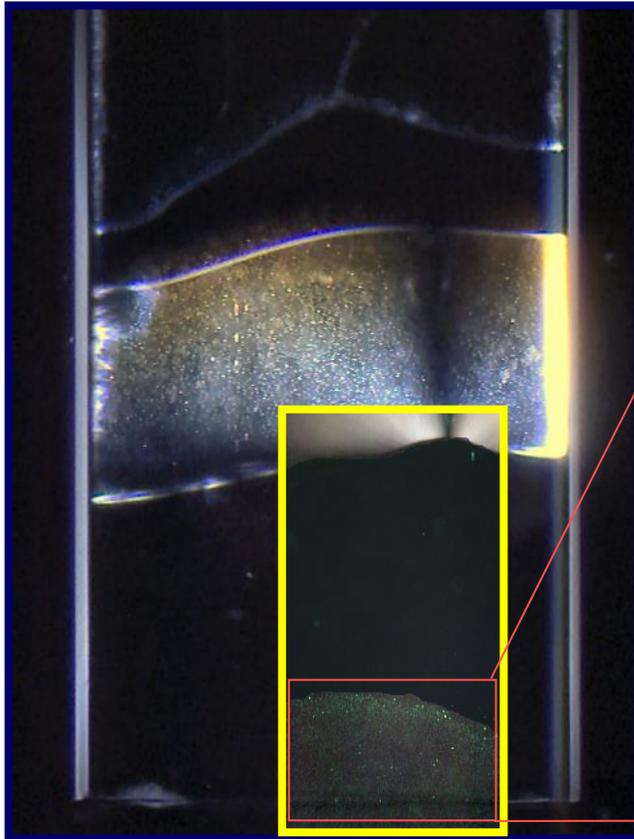
# Colloidal tracers map invisible structural boundaries



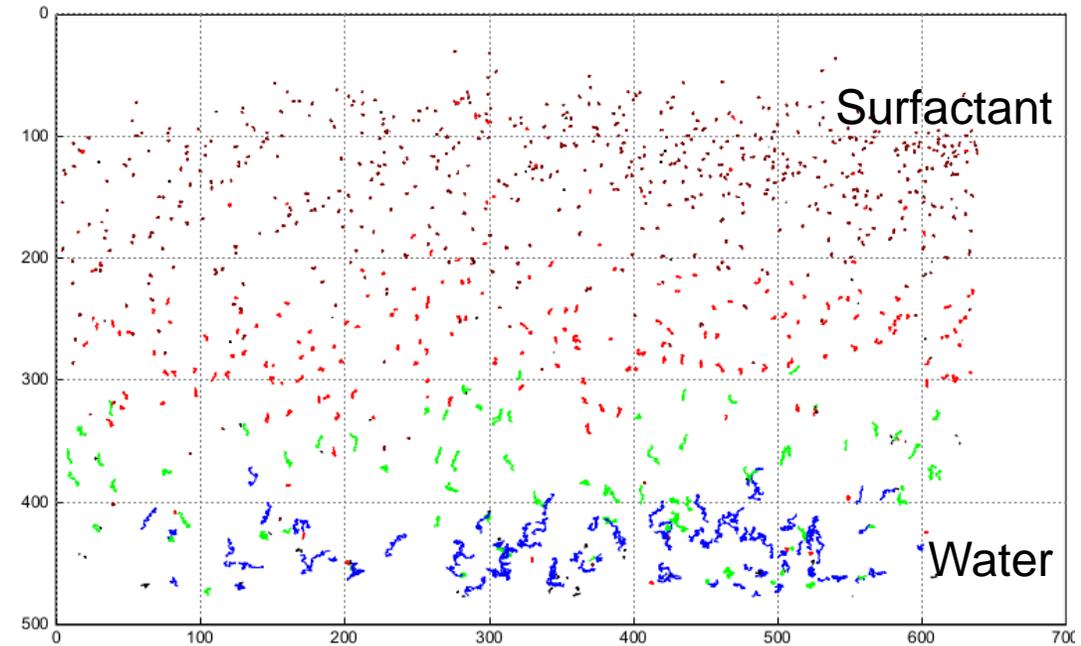
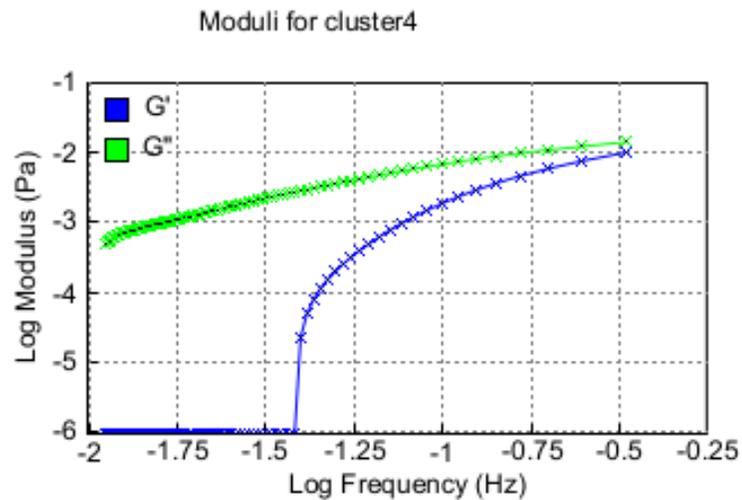
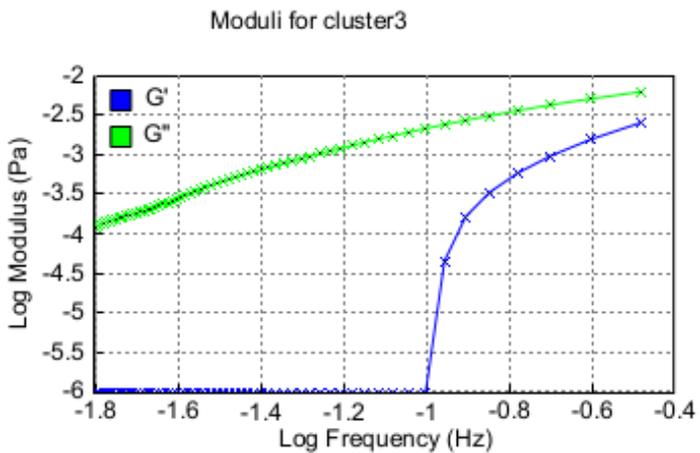
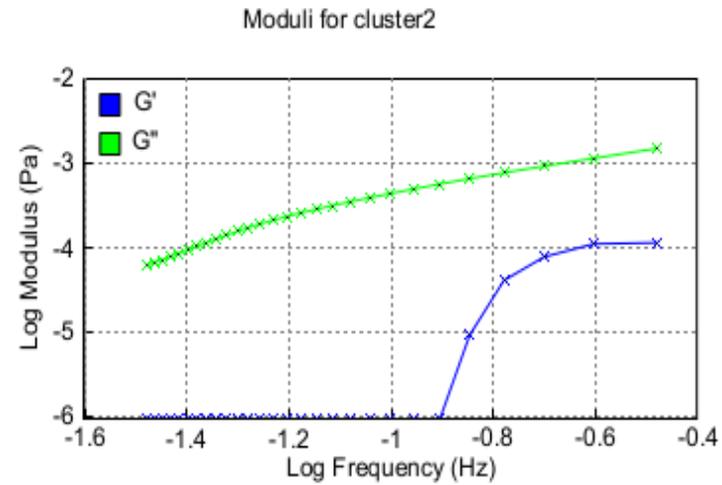
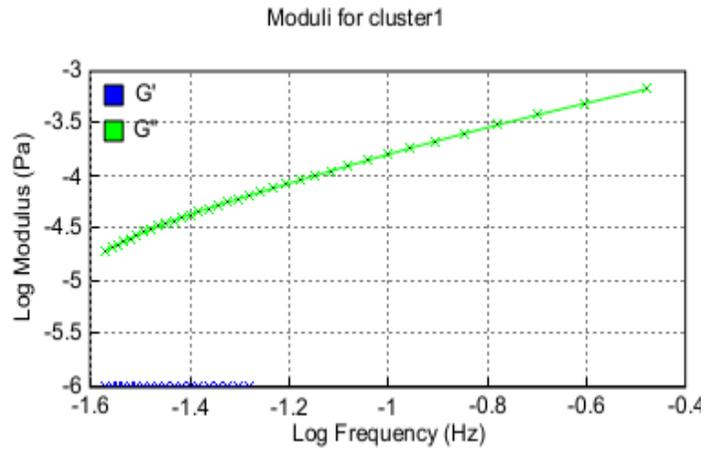
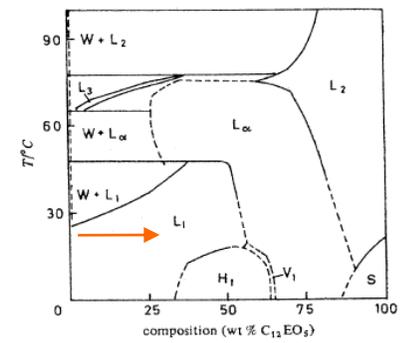
Here the rate of tracer flow in provides a rough mass balance. Water flux and interface velocity used to argue cylindrical micelle packing is rate-limiter.

Buchanan et al., Langmuir, 16, 3718-3726 (2000).

# Particle tracking maps structure



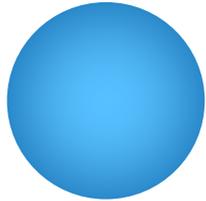
# Microrheology quantifies capillary swelling



# Midpoint message

- Small, simple, but quantitative measures of reconstitution flows and compositions provide the mechanistic insights needed for a mental model of performance.
- As products and materials increase in complexity and concentration, there is more need for structural adaptations of materials and their response.

1960-1970



10-30%

**United States Patent** [19] (11) **4,452,732**  
**Bolich, Jr.** [45] **Jun. 5, 1984**

[54] **SHAMPOO COMPOSITIONS** 3,223,645 12/1965 Kalberg ..... 252/117  
 3,274,106 9/1966 Seamus ..... 252/547  
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 4,102,825 6/1978 Marano et al. .... 252/DIG. 13  
 4,379,753 6/1983 Bolich, Jr. .... 252/DIG. 13

[73] Assignee: **The Procter & Gamble Company,**  
 Cincinnati, Ohio

[21] Appl. No.: **446,840**  
 [22] Filed: **Dec. 6, 1982**

**Related U.S. Application Data**  
 Continuation of Ser. No. 274,009, Jan. 15, 1981, abandoned.

[51] Int. Cl. .... **C10D 1/62**  
 [52] U.S. Cl. .... **252/947; 252/945; 252/117; 252/DIG. 13; 252/DIG. 14; 424/70**  
 [58] **Field of Search** ..... **252/547; 545; 546; 548; 252/DIG. 13; 117; DIG. 14; 424/70**

[56] **References Cited**  
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 3,156,656 11/1964 Libby ..... 252/DIG. 13

**OTHER PUBLICATIONS**  
 Solubility-Temperature Coefficient, Surface Active Agents, Schwartz & Perry, pp. 302-303, 1949, Interscience Publisher, Inc., New York.

**Primary Examiner**—John E. Kittle  
**Assistant Examiner**—Hoa Van Le  
**Attorney, Agent, or Firm**—Richard C. Witte, John V. Gloman, Douglas C. Mohl

**ABSTRACT**  
 Shampoo compositions containing unsaturated tertiary ammonium compounds which compositions exhibit improved low temperature stability due to the inclusion of a long chain acyl derivative.

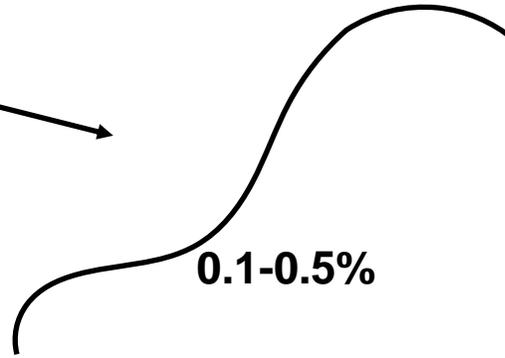
**8 Claims, No Drawings**

1970-2000



1-3%

2000-now



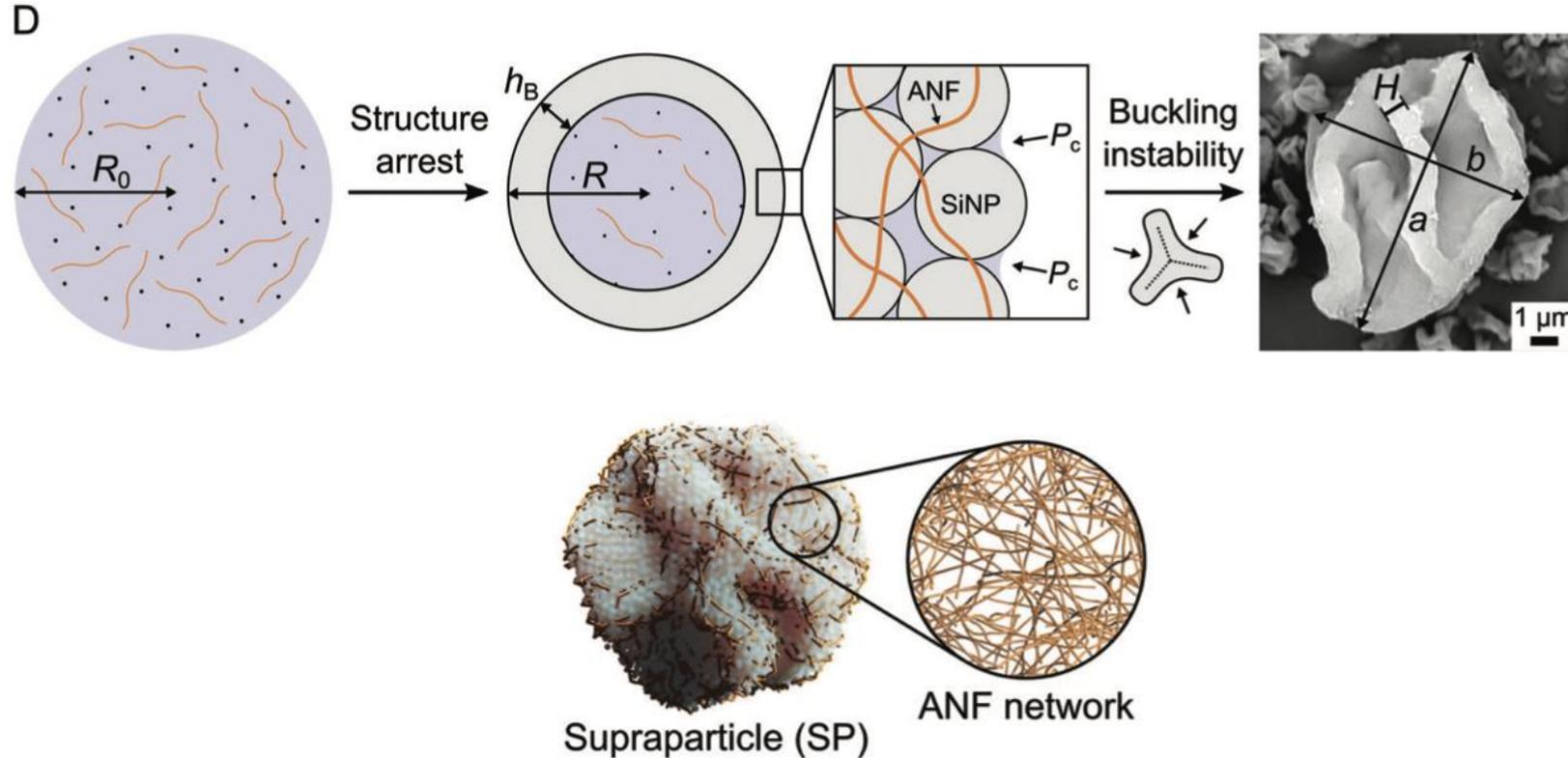
**United States Patent** [19] (11) **Patent Number: 5,885,948**  
**Glenn, Jr. et al.** [45] **Date of Patent: \*Mar. 23, 1999**

[54] **CRYSTALLINE HYDROXY WAXES AS OIL-IN-WATER STABILIZERS FOR SKIN CLEANSING LIQUID COMPOSITION** 5,044,401 6/1991 Katsuki et al. .... 424/80  
 5,075,414 10/1991 Dzialo et al. .... 424/70  
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 5,352,387 10/1994 Rahms et al. .... 252/546  
 5,374,265 7/1995 Kaeber et al. .... 424/80  
 5,381,104 12/1994 Ha et al. .... 424/80  
 5,674,211 10/1997 Kaeber et al. .... 424/80  
 5,756,207 2/1998 Glenn, Jr. et al. .... 510/159

[73] Assignee: **The Procter & Gamble Company,**  
 Cincinnati, Ohio

[51] Int. Cl. .... **A61K 9/00; A61K 7/00; A61K 31/00; A61K 31/02; A61K 31/04; A61K 31/06; A61K 31/08; A61K 31/10; A61K 31/12; A61K 31/14; A61K 31/16; A61K 31/18; A61K 31/20; A61K 31/22; A61K 31/24; A61K 31/26; A61K 31/28; A61K 31/30; A61K 31/32; A61K 31/34; A61K 31/36; A61K 31/38; A61K 31/40; A61K 31/42; A61K 31/44; A61K 31/46; A61K 31/48; A61K 31/50; A61K 31/52; A61K 31/54; A61K 31/56; A61K 31/58; A61K 31/60; A61K 31/62; A61K 31/64; A61K 31/66; A61K 31/68; A61K 31/70; A61K 31/72; A61K 31/74; A61K 31/76; A61K 31/78; A61K 31/80; A61K 31/82; A61K 31/84; A61K 31/86; A61K 31/88; A61K 31/90; A61K 31/92; A61K 31/94; A61K 31/96; A61K 31/98; A61K 32/00; A61K 32/02; A61K 32/04; A61K 32/06; A61K 32/08; A61K 32/10; A61K 32/12; A61K 32/14; A61K 32/16; A61K 32/18; A61K 32/20; A61K 32/22; A61K 32/24; A61K 32/26; A61K 32/28; A61K 32/30; A61K 32/32; A61K 32/34; A61K 32/36; A61K 32/38; A61K 32/40; A61K 32/42; A61K 32/44; A61K 32/46; A61K 32/48; A61K 32/50; A61K 32/52; A61K 32/54; A61K 32/56; A61K 32/58; A61K 32/60; 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# Amyloid nanofibrils as structural and functional inclusion in spray dried “supraparticles”

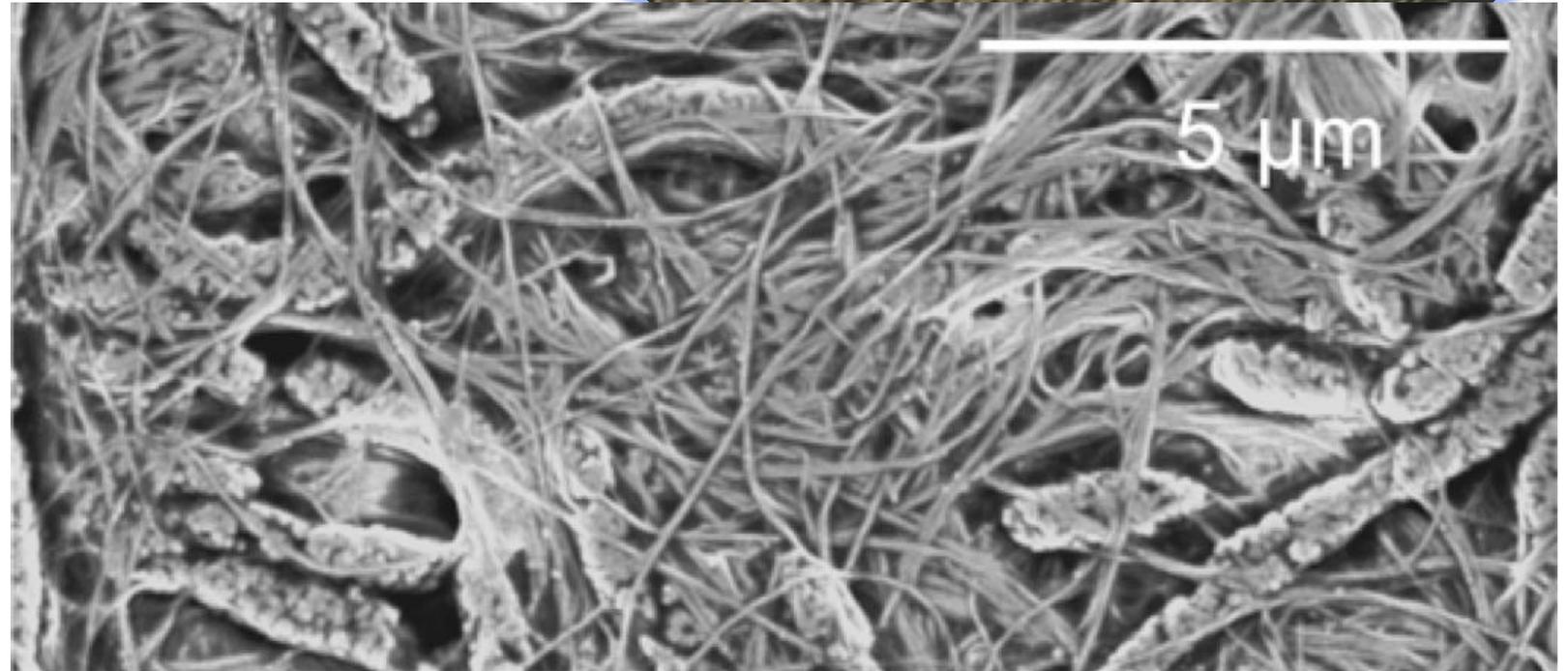
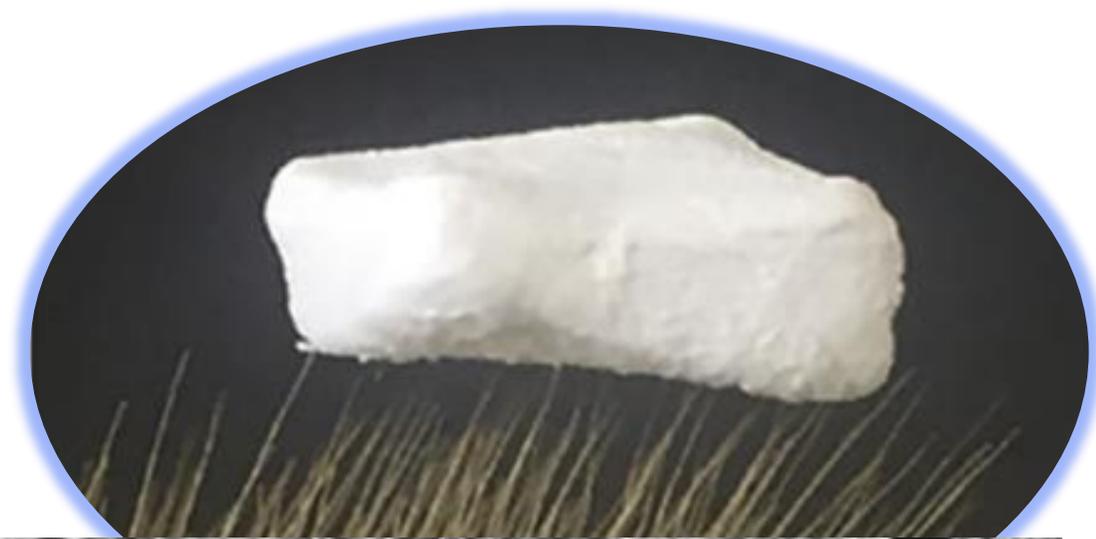


Fibril particles added to the mixture improve cohesion, making stronger dried films at the surface.

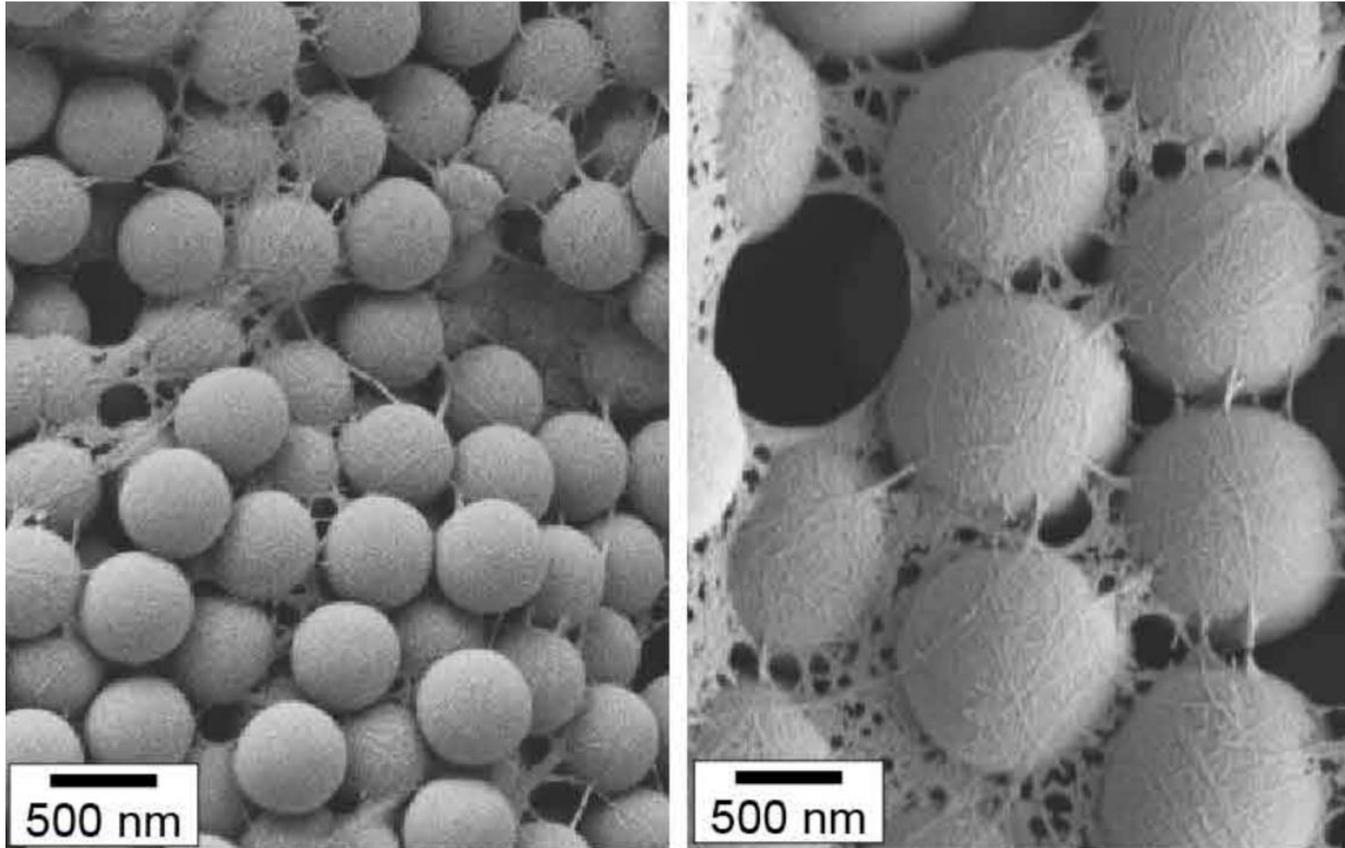
Buckling is desired here to improve hydr. Diameter aerosol performance and S/V ratio, as well as ensure buckling.

Kämäräinen et al., *Small*, .2309645 (2024).

# Bacterial nanocellulose



# Inorganic compacts via strength of structural adhesion

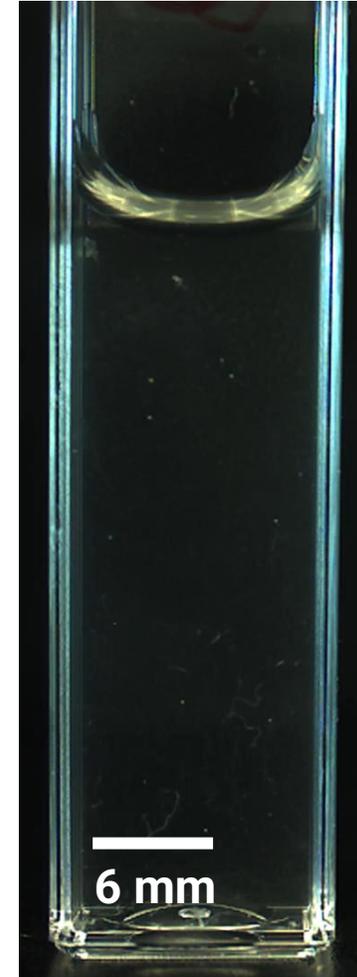
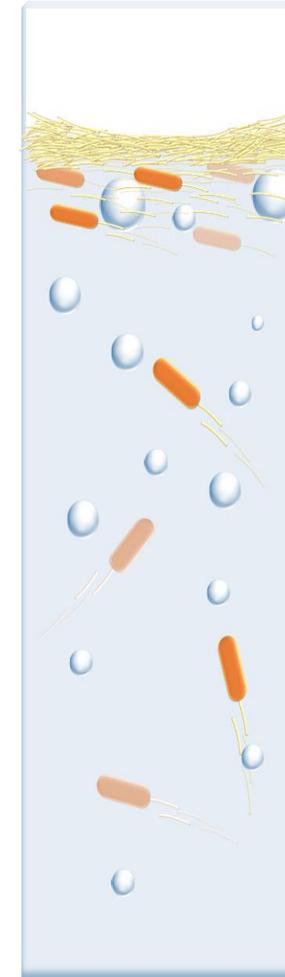
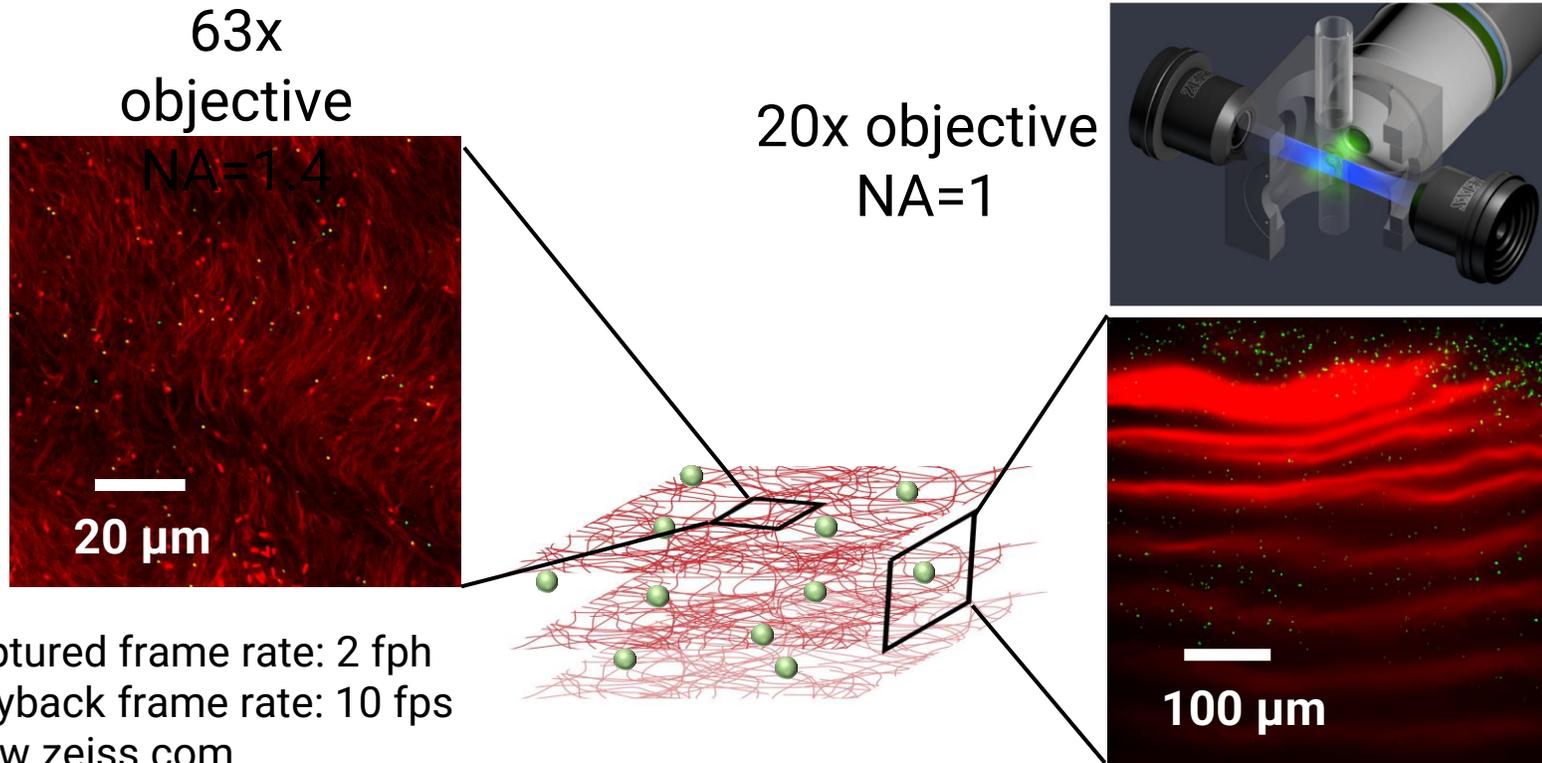


Strength of attractive interactions between fibers produces compacts with strengths comparable to sintered materials

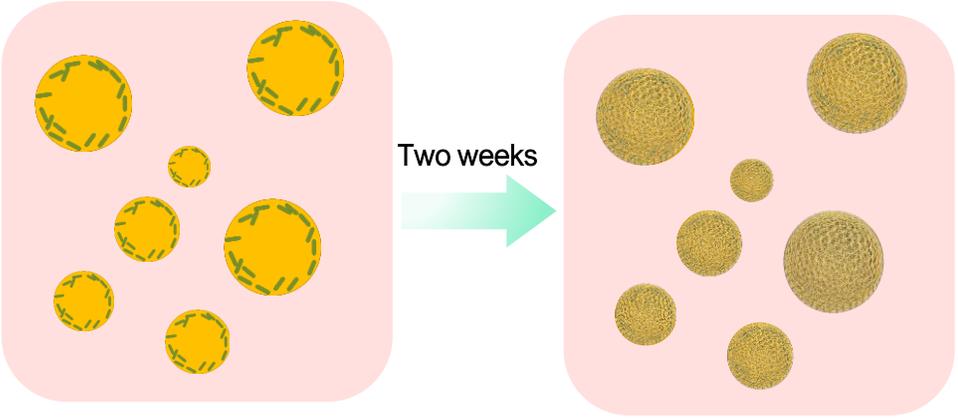
Science advances, 6(19), p.eaaz7328.

# Cellulose biofilm/pellicles formed by *Acetobacter xylinum*

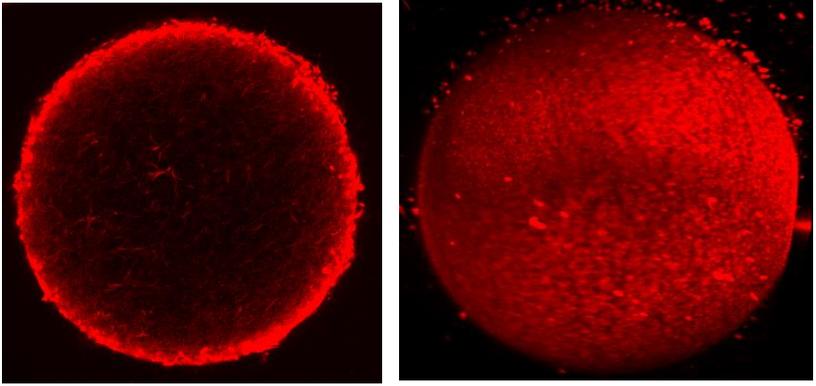
- Microstructure of the biofilms formed in different media are imaged using SEM, Lightsheet and confocal microscopy.
- Biofilms are immersed in different solutions of polystyrene particles with diameter of  $D = 0.2, 0.5$  and  $1 \mu\text{m}$ .



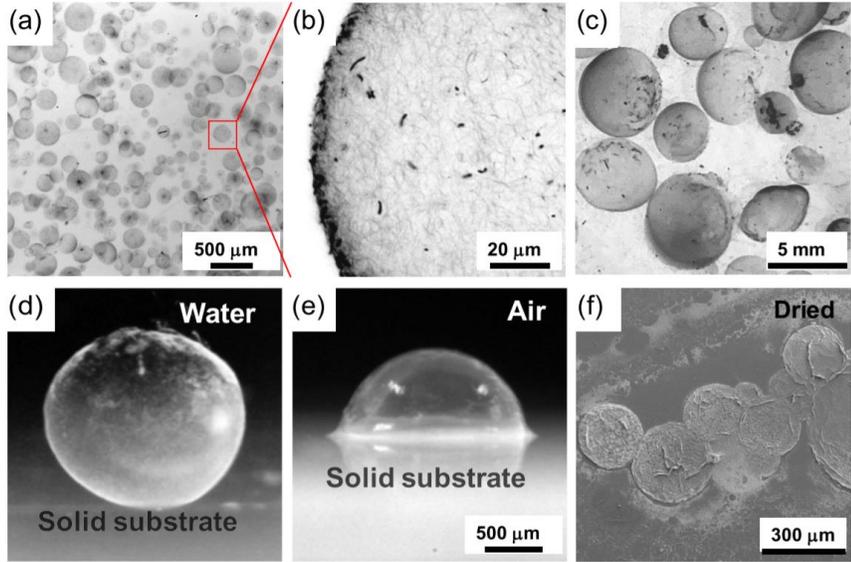
# Cellulose microcapsules



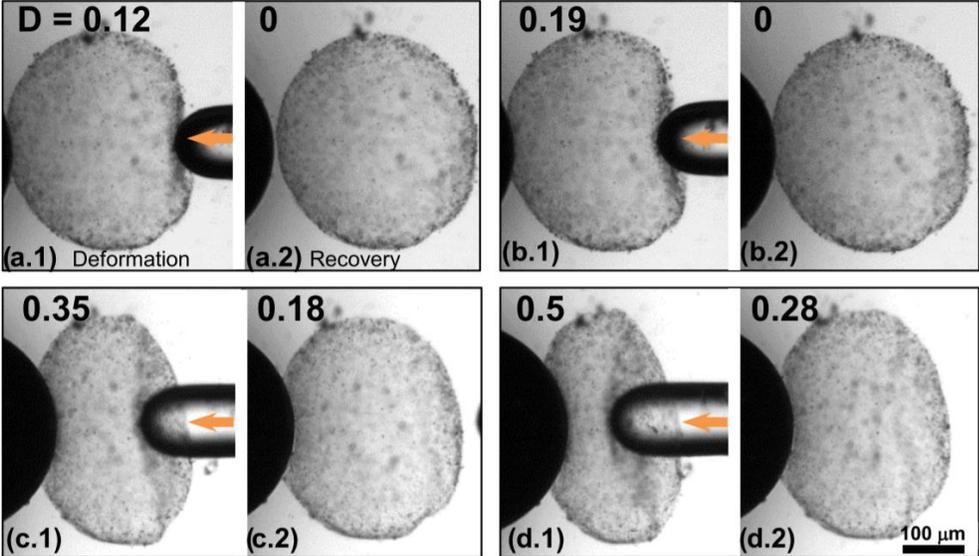
*Acetobacter xylinum* bacterial culture is dispersed into droplets in a gelled oil phase



Pore sizes between 0.5  $\mu\text{m}$  - 1  $\mu\text{m}$

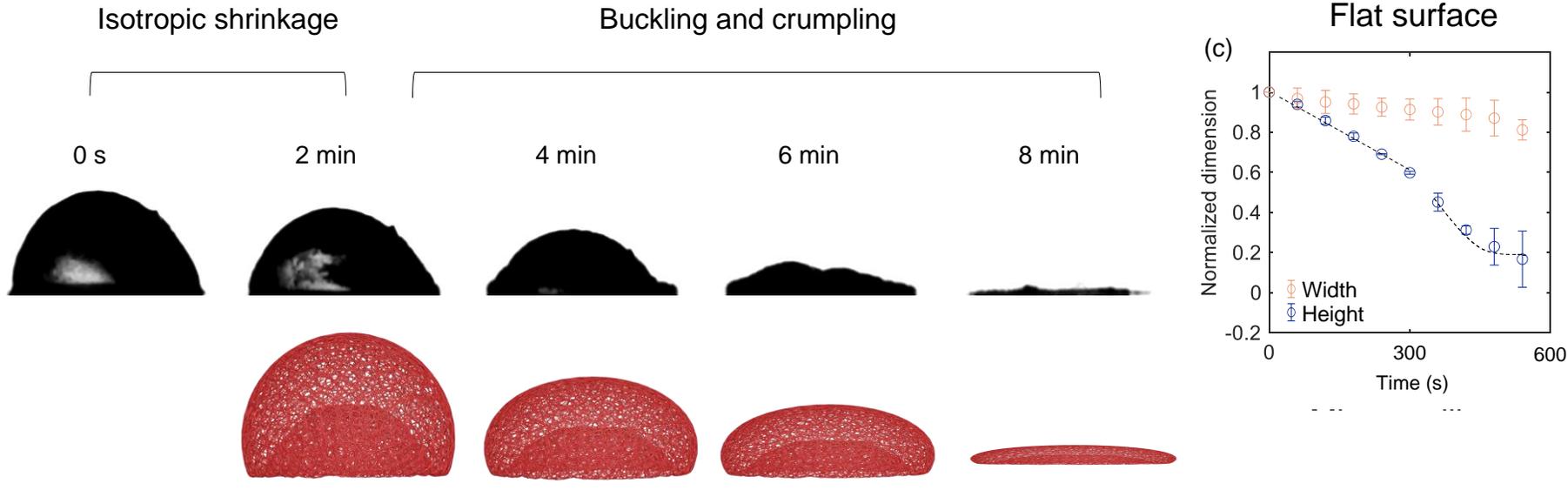


Wall density less than 1% solid, so overall capsule has minimal mass

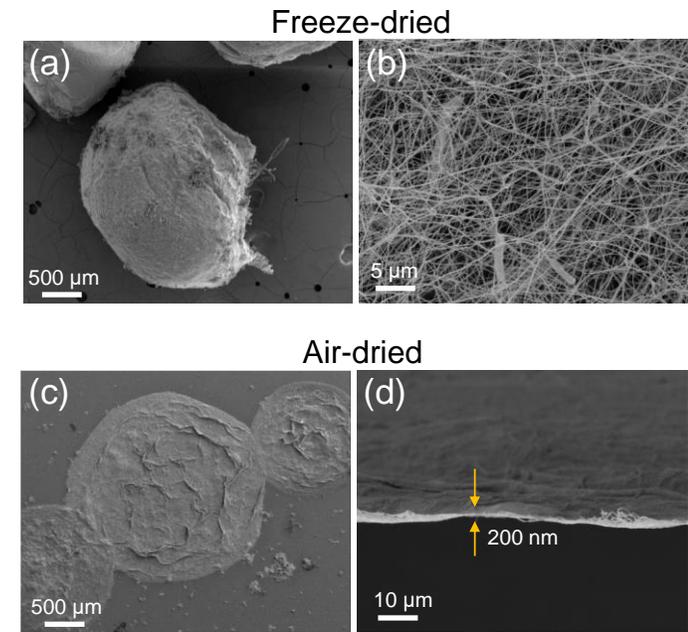


Low elastic modulus around 100 Pa

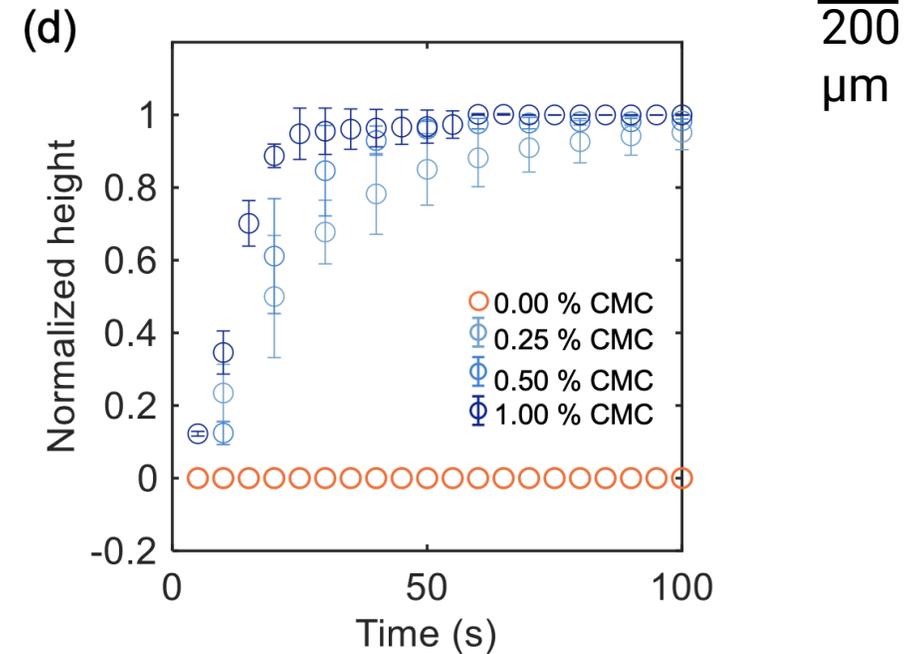
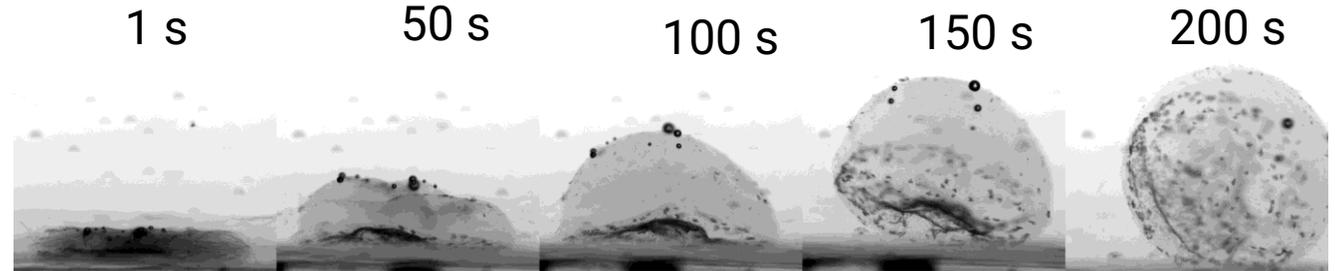
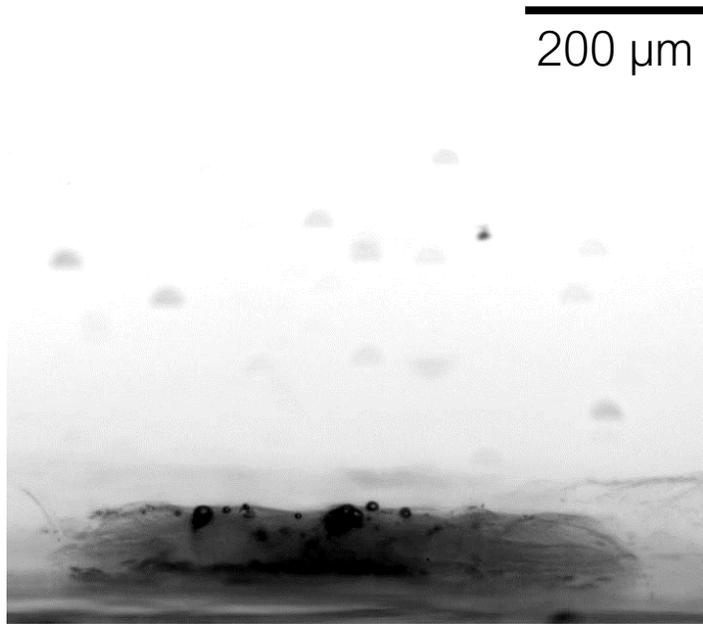
# Cellulose aerogel capsule drying



Millimeter-scale capsule dries to nanometer dimensions purely by capillary forces. Transition is irreversible unless surface interactions are reduced.



# Cellulose aerogel capsule swelling



Recovery of shape is complete from a fully flattened film. Same recovery in a powder matrix with active materials encapsulated would speed mixing and ease reconstitution.

# Insights

- New, as well as traditional, material and product forms require understanding of complex phenomena and their rates for formulation, scale-up, and use specs.
- Simple measurements, coupled with knowledge of structure and formulation designs, provide rapid assessment of even complex mixtures.
- Response of powder particles during reconstitution may add function and resilience for new formulations and design.