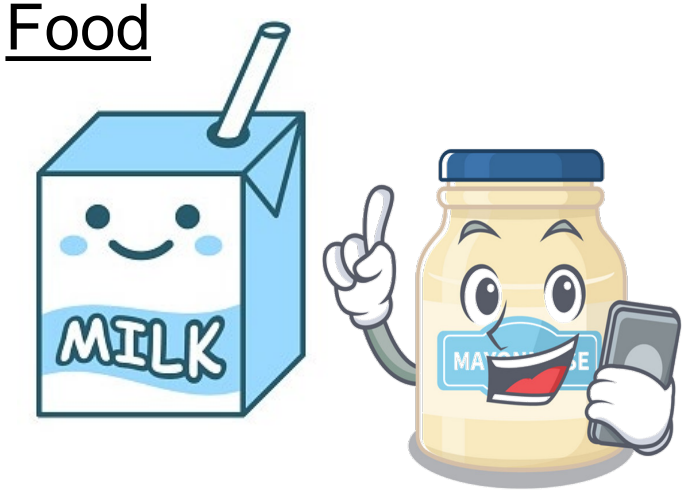
Bicontinuous emulsions from renewable nanoparticle

Yi LU, Shasha Guo, Milad Kamkar, Orlando J. Rojas

Emulsions are the mixture of immiscible liquids

Food

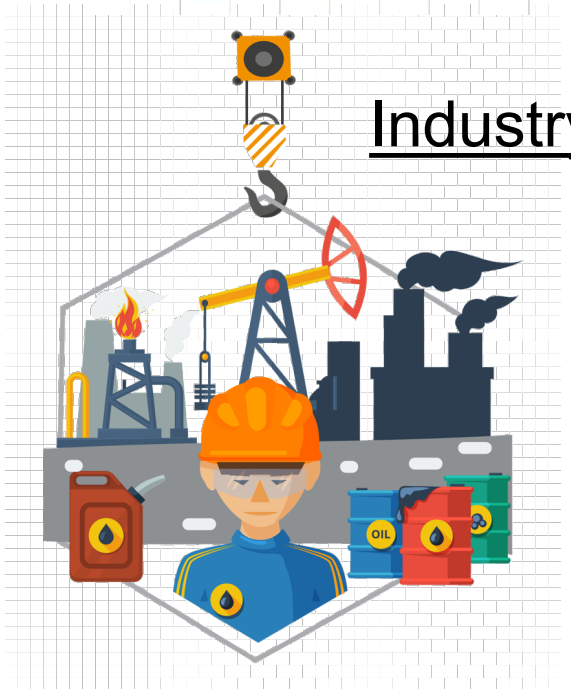


Personal care

Cosmetic

Health

Industry



Images from Internet:
https://www.istockphoto.com/
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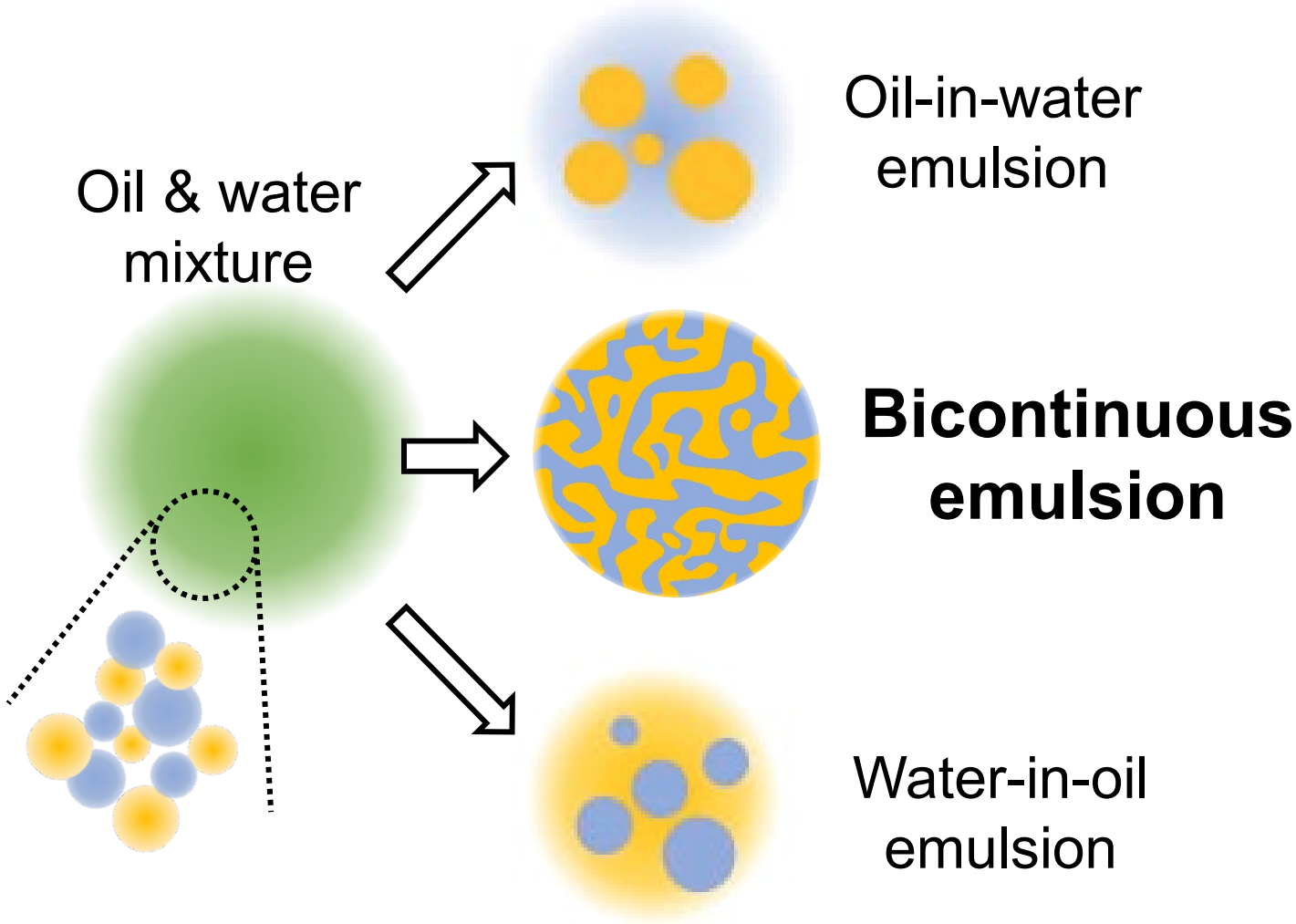
https://vhv.rs

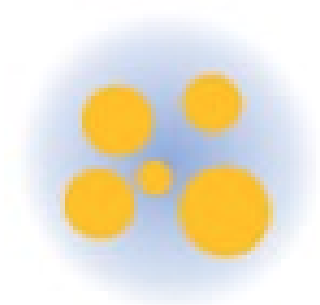
Ashaolu, T.J., Environmental Chemistry Letters volume 19, pages3381–3395 (2021)

Bicontinuous emulsion vs. Regular emulsions

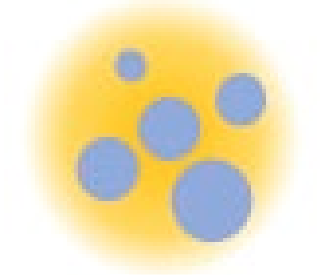


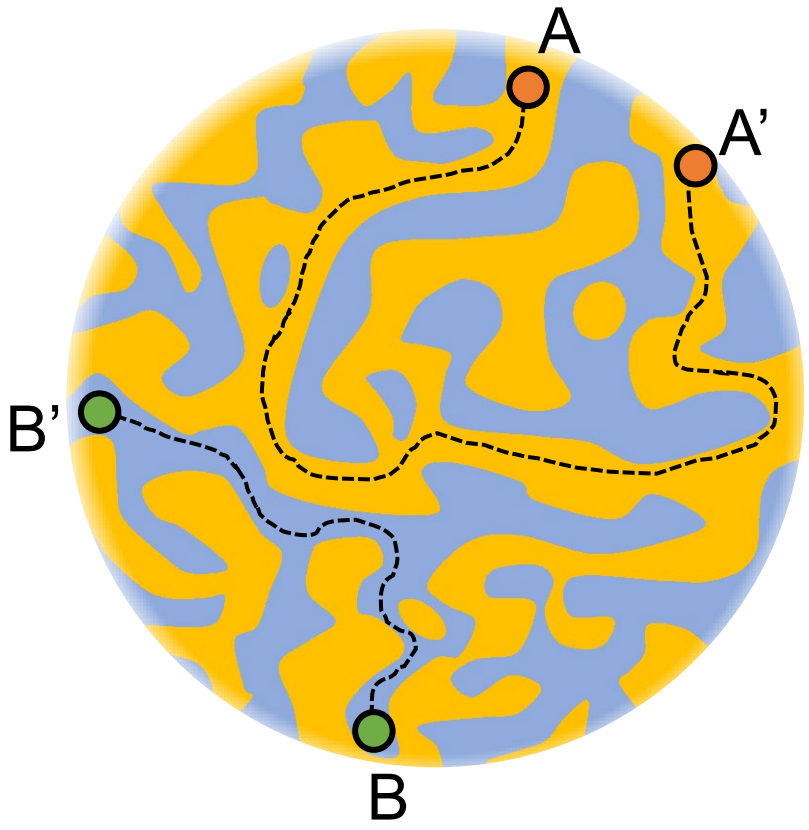
Why bicontinuous emulsions?

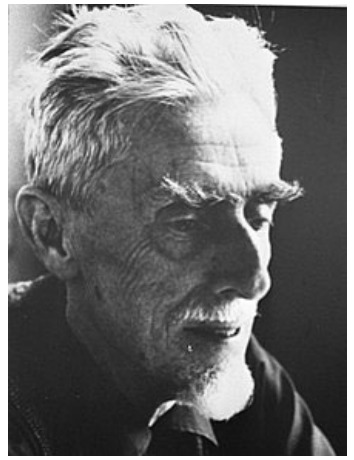
(1) Continuous reactions in multi-phase systems



Regular emulsions







M. C. Escher

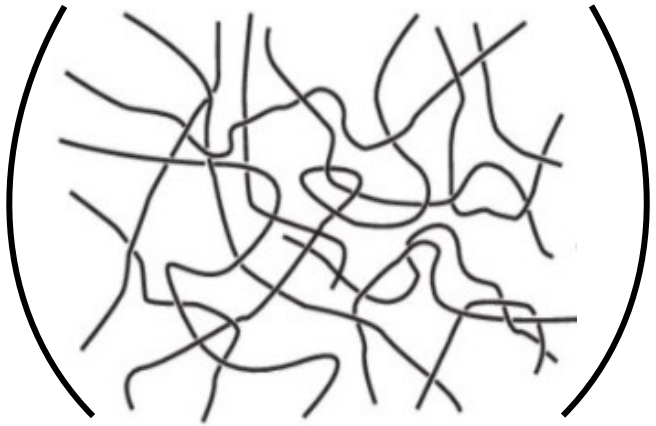
(1898 – 1972)

Dutch graphic artist

https://en.wikipedia.org/wiki/M._C._Escher

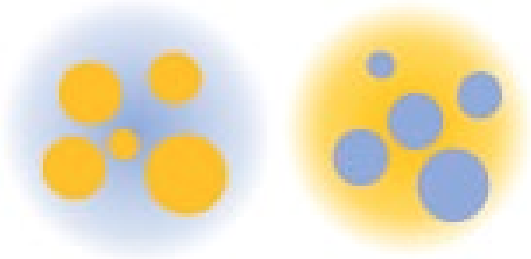
Why bicontinuous emulsions?

(2) Material strength

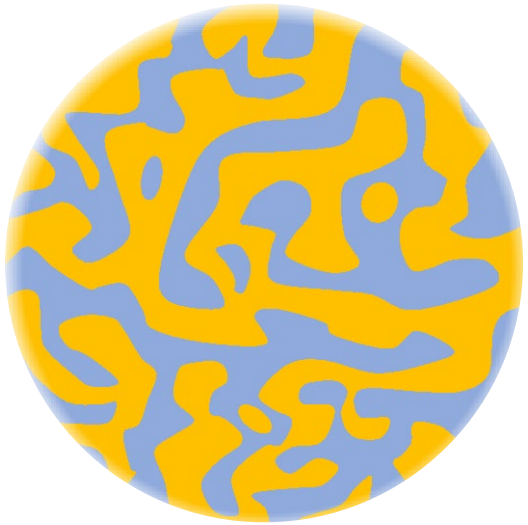


Entangled
polymer network

Regular emulsion



Bicontinuous emulsion

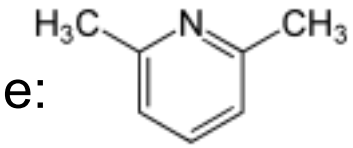


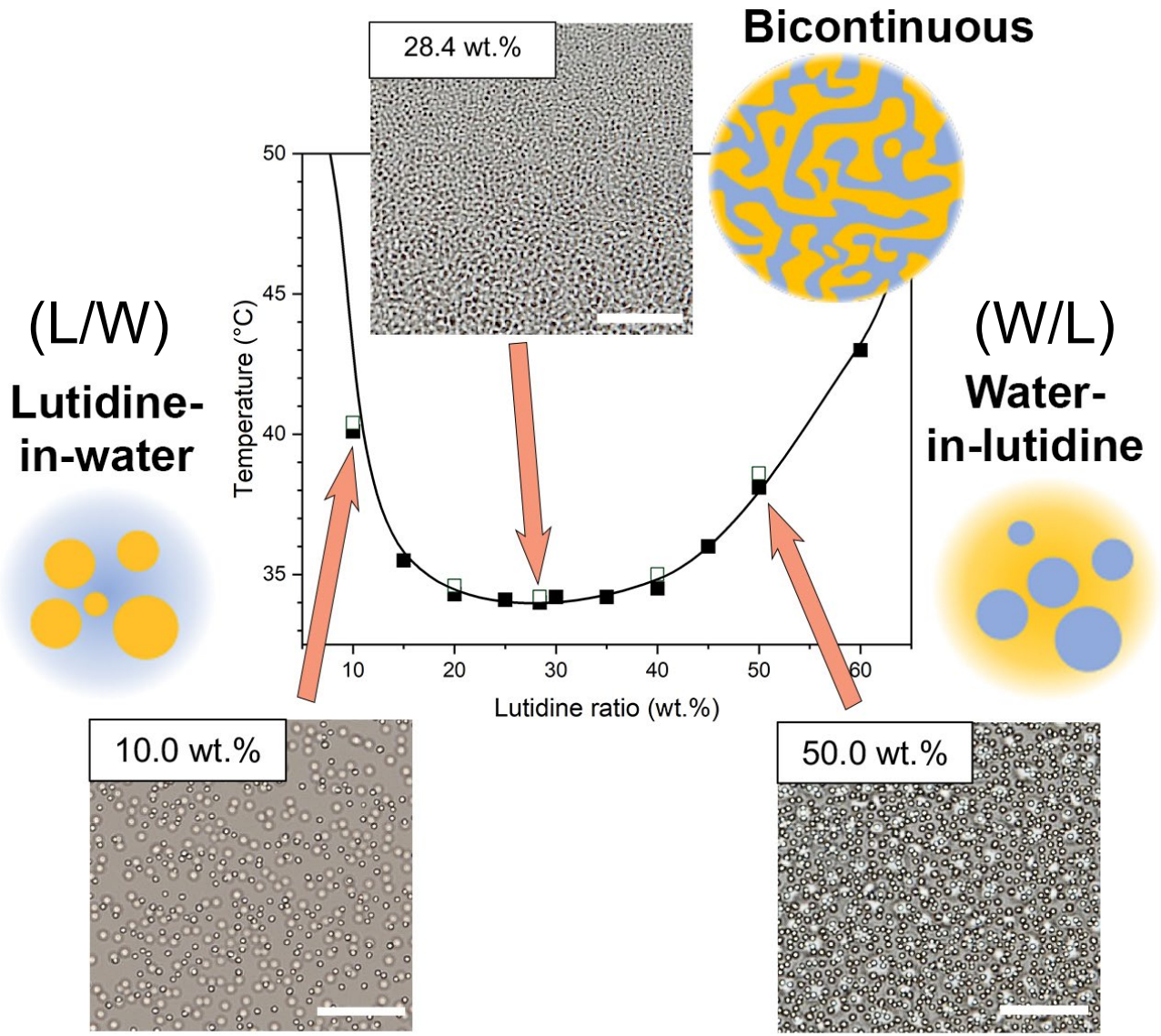
(3) Large interfacial area

https://commons.wikimedia.org/wiki/File:Finland_adm_map_1935.svg

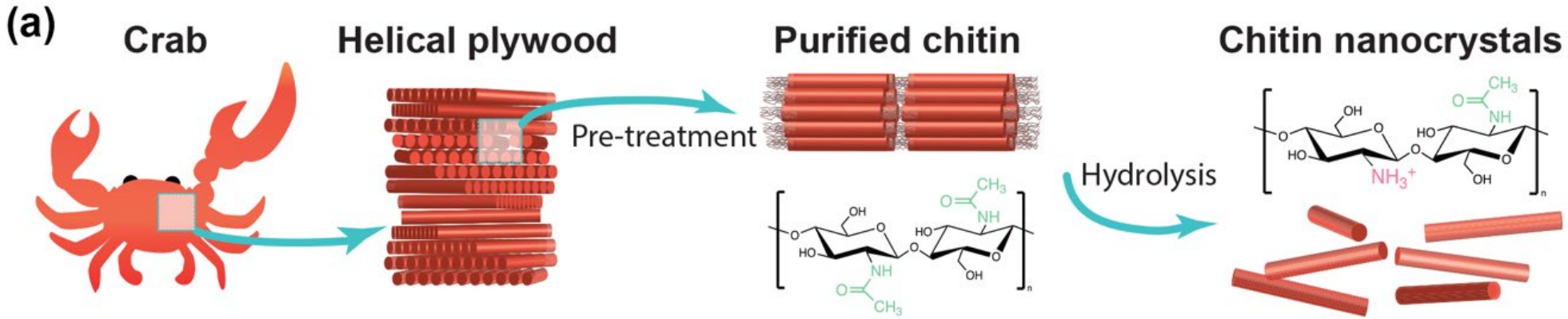
Water-lutidine system

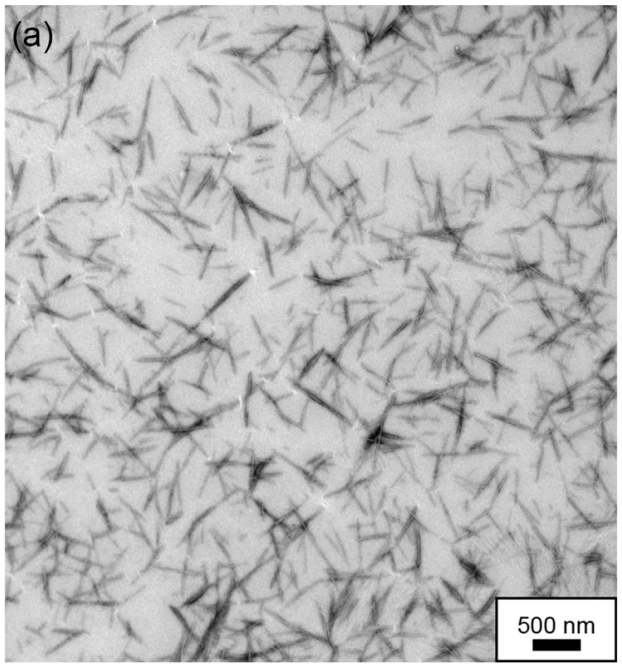
2,6-Lutidine:



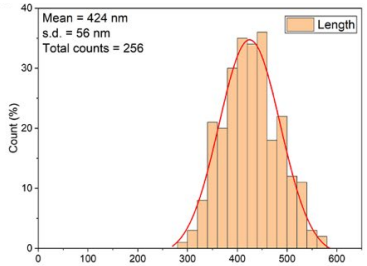


Extraction of chitin nanocrystal (ChNC)

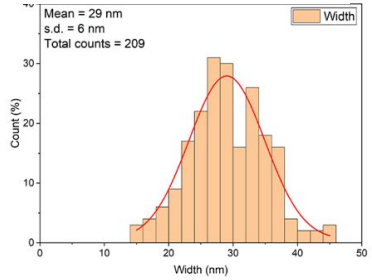




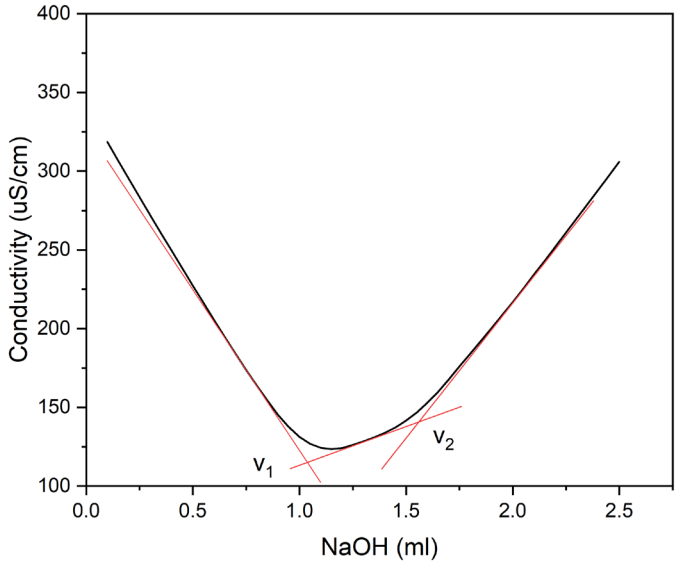
Length ~424 nm



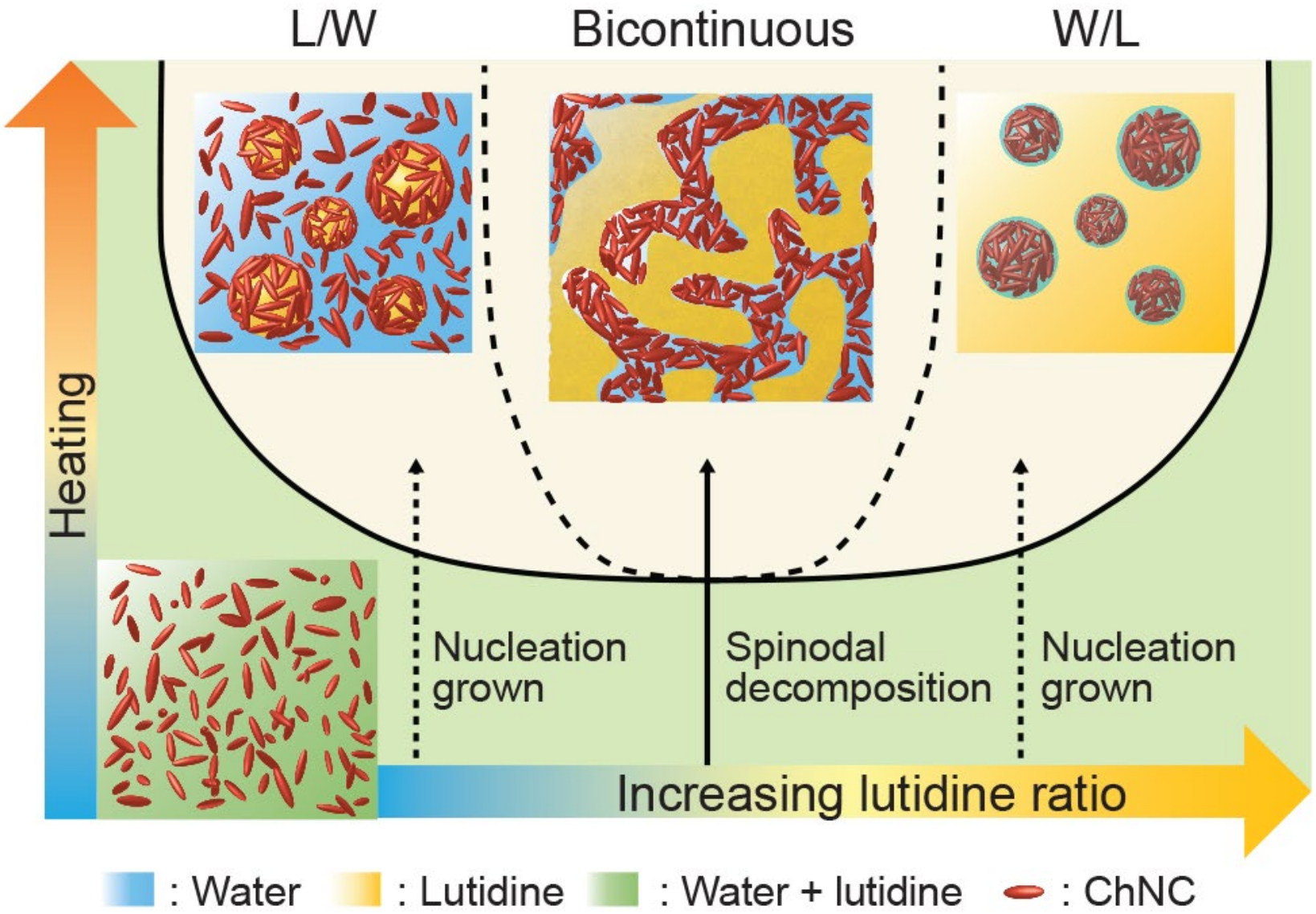
Width ~29 nm



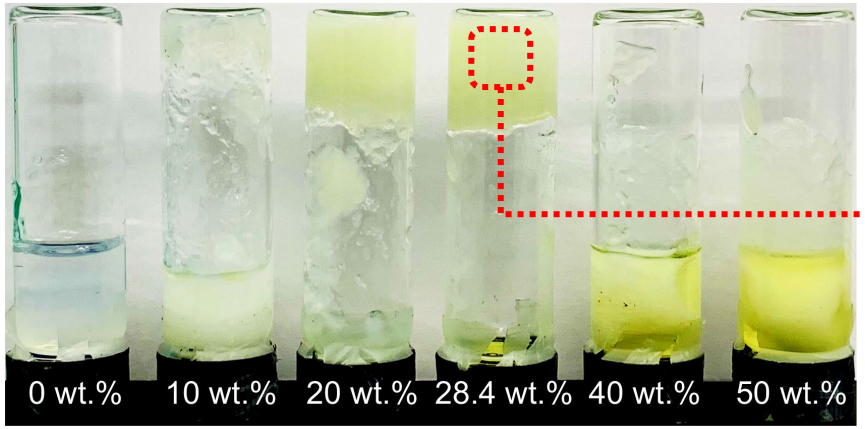
Degree of deacytelyation ~4.42%



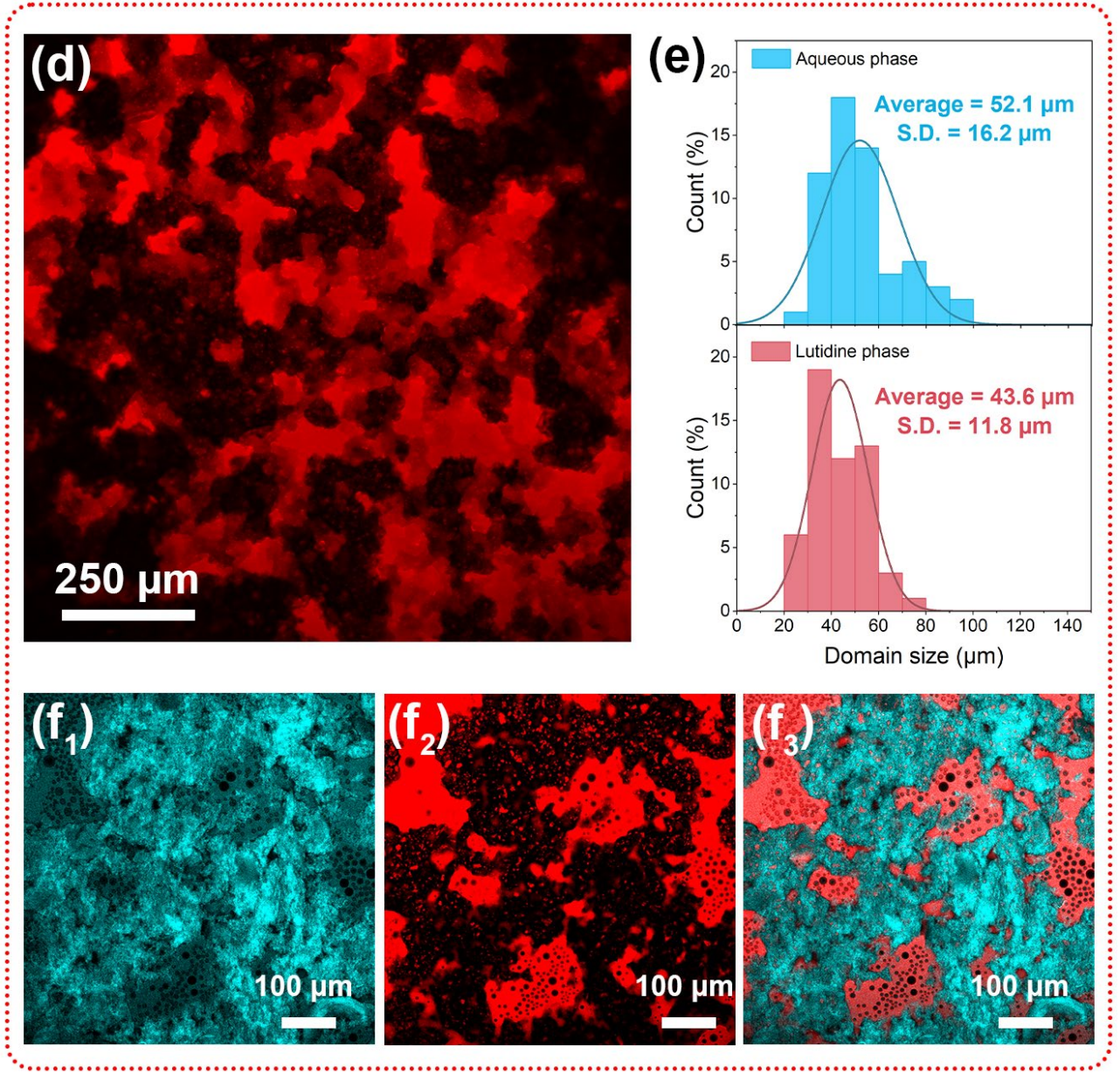
Jamming the bicontinuous morphology by ChNC



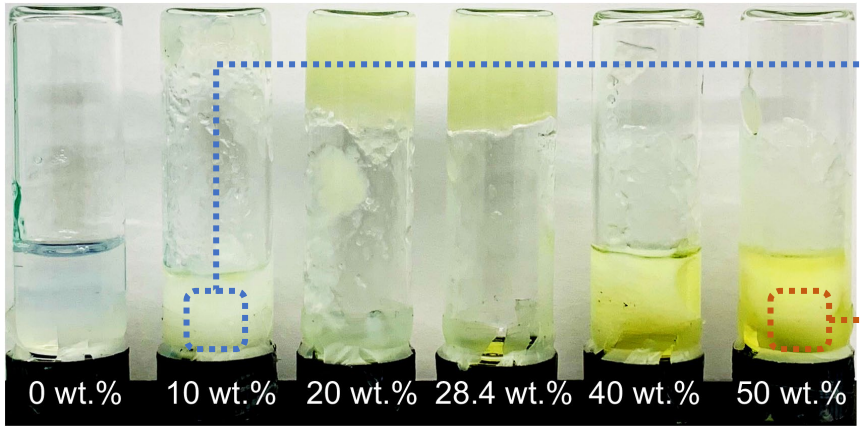
ChNC-jammed bicontinuous emulsion



- Bicontinuous emulsion was successfully generated at critical lutidine ratio;
- ChNCs were jammed in the aqueous phase.



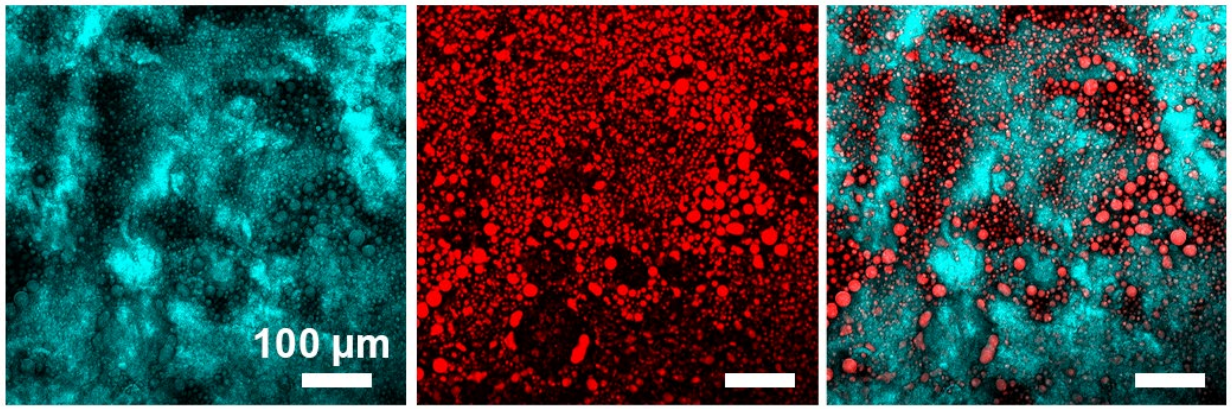
ChNC-jammed regular emulsions



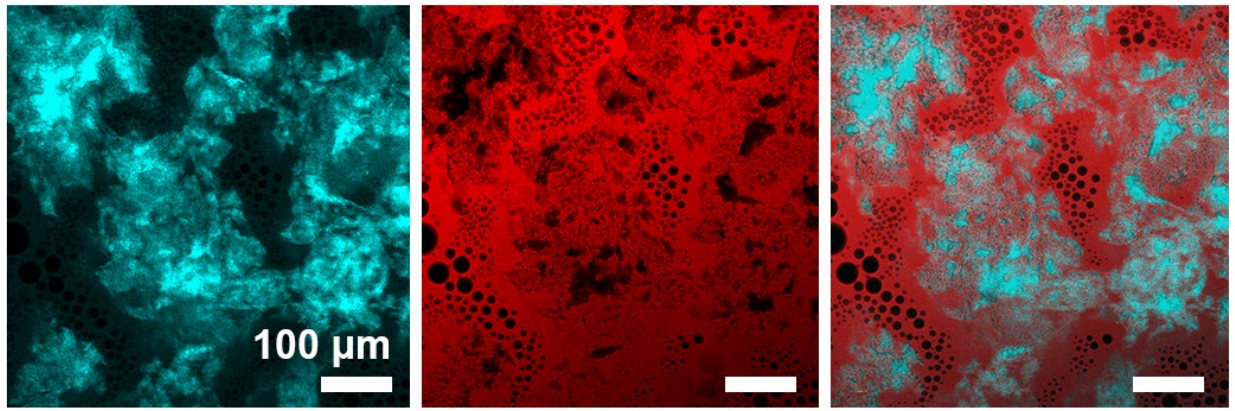
L/W

W/L

10 wt.% lutidine

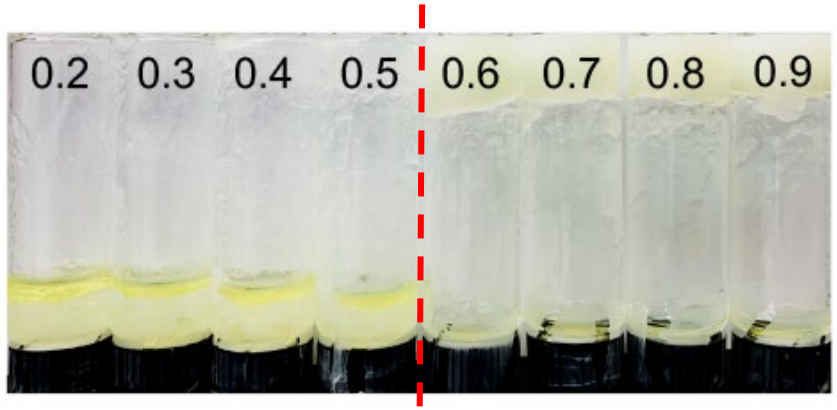


50 wt.% lutidine

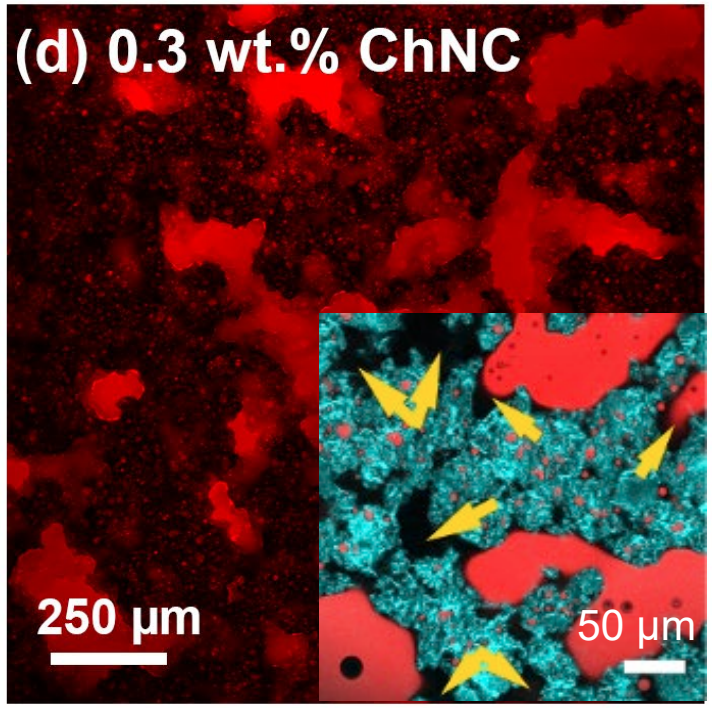


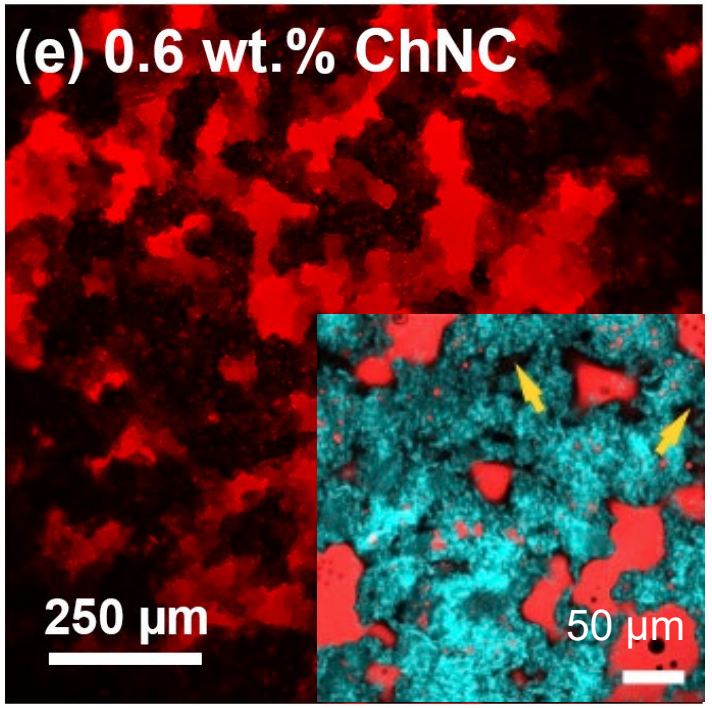
At non-critical lutidine ratios, regular emulsions were formed.

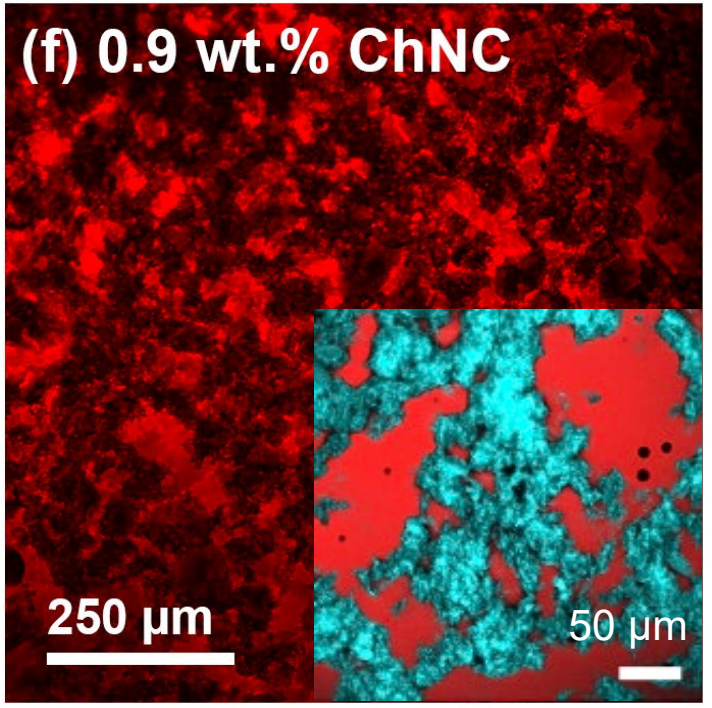
ChNC-jammed bicontinuous emulsion



- ChNC concentration needed to be greater than 0.6 wt.%;
- Changing ChNC concetration could tune the domain sizes.

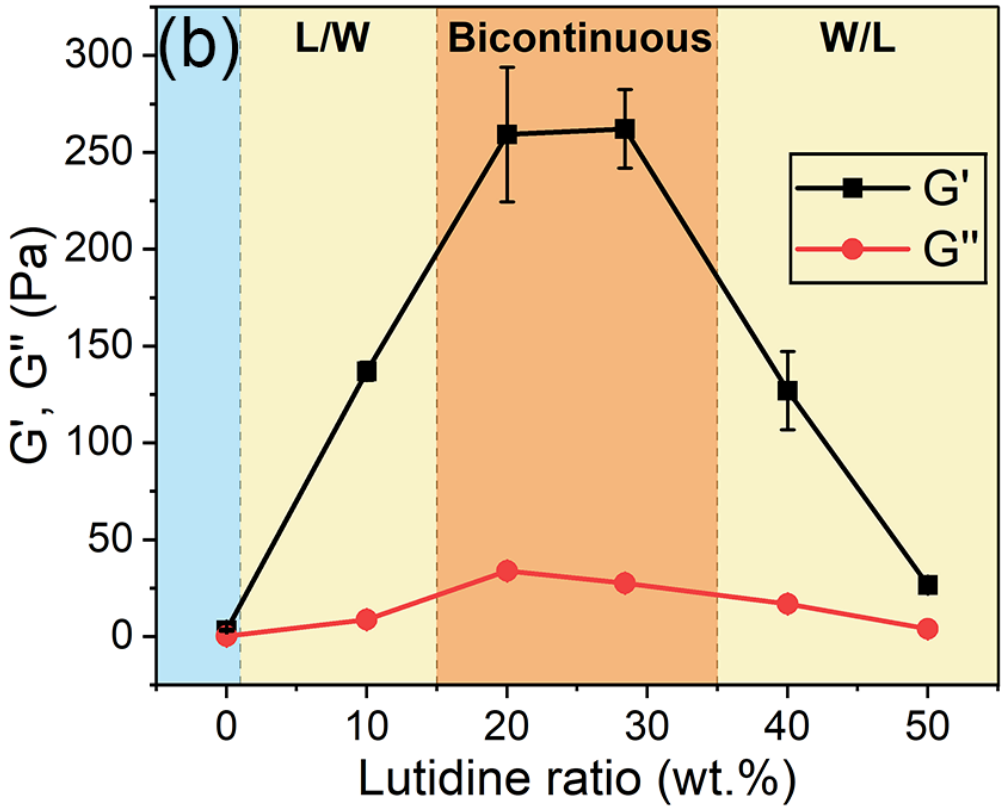


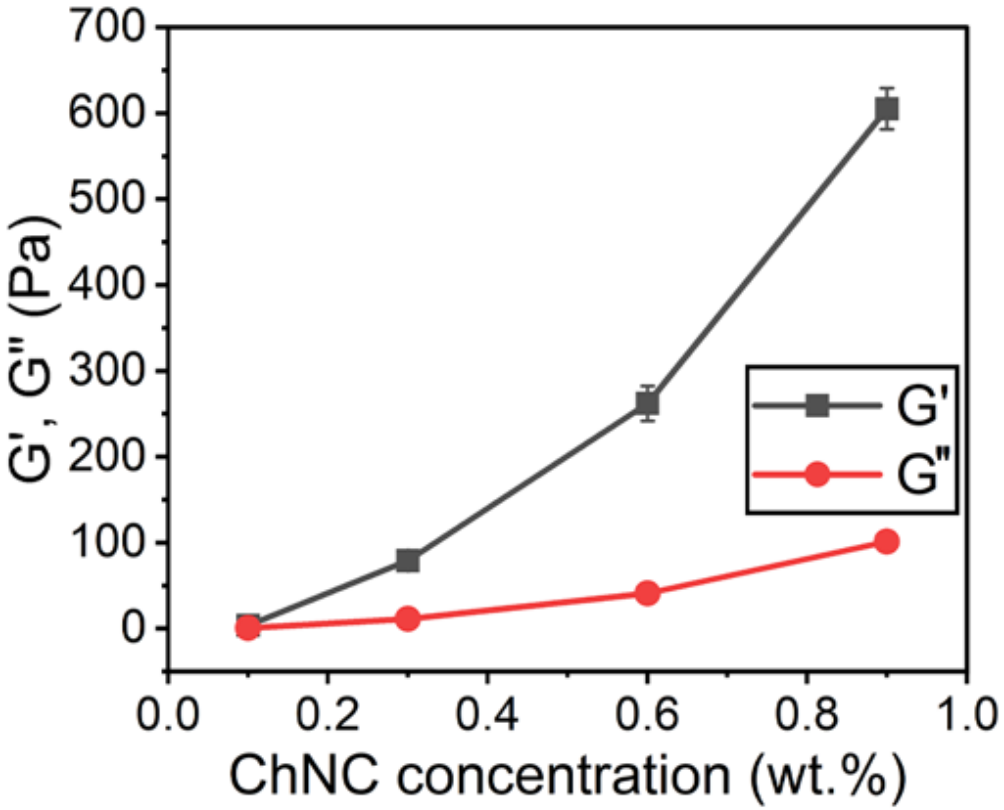




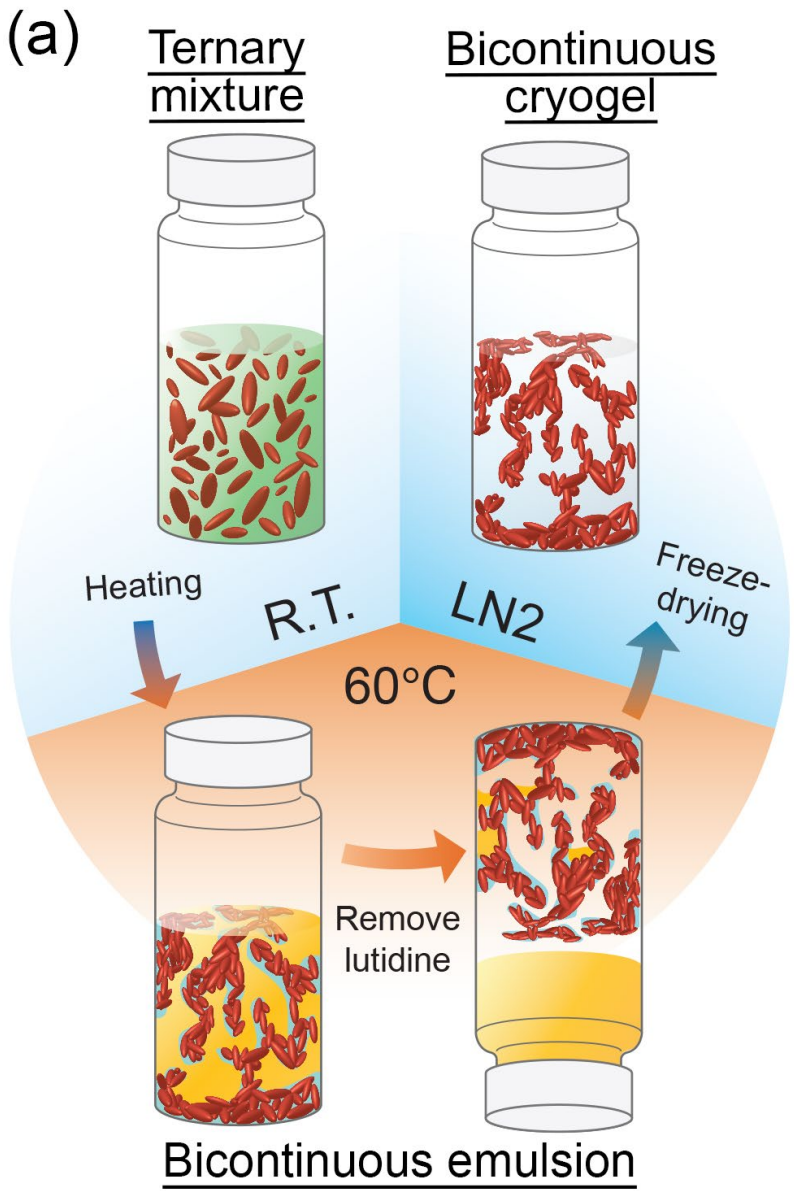
Rheology of bicontinuous emulsion

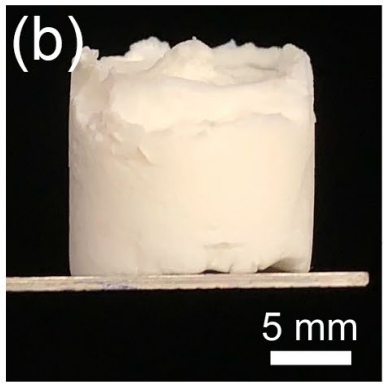
- Bicontinuous emulsion out-perform regular emulsions in strength;
- More ChNC loading leads to stronger emulsion.

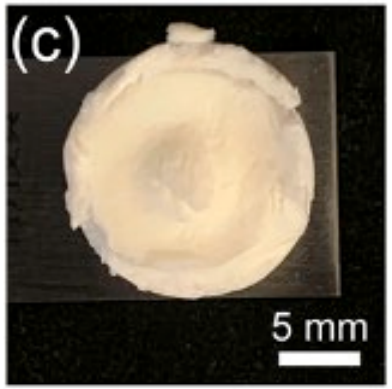


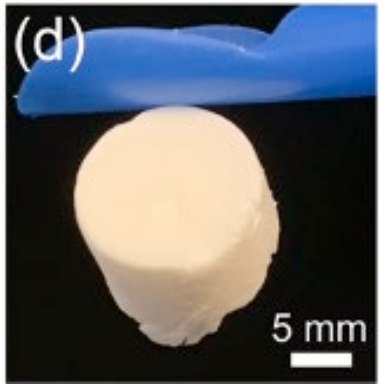


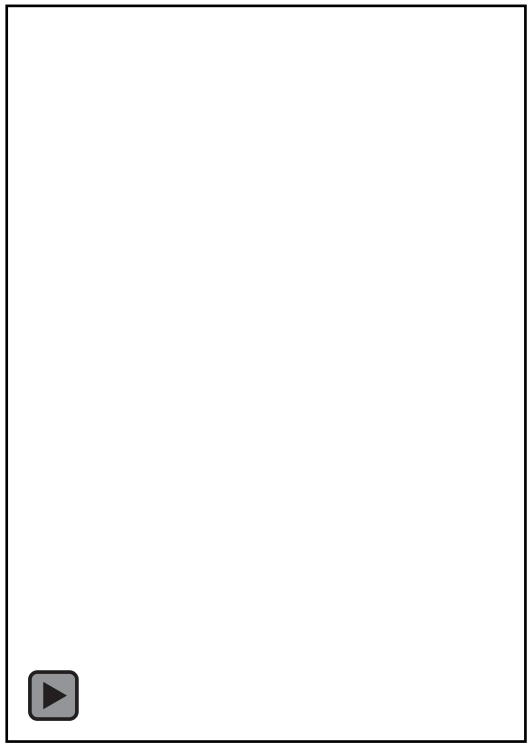
Bicontinuous chitin cryogel





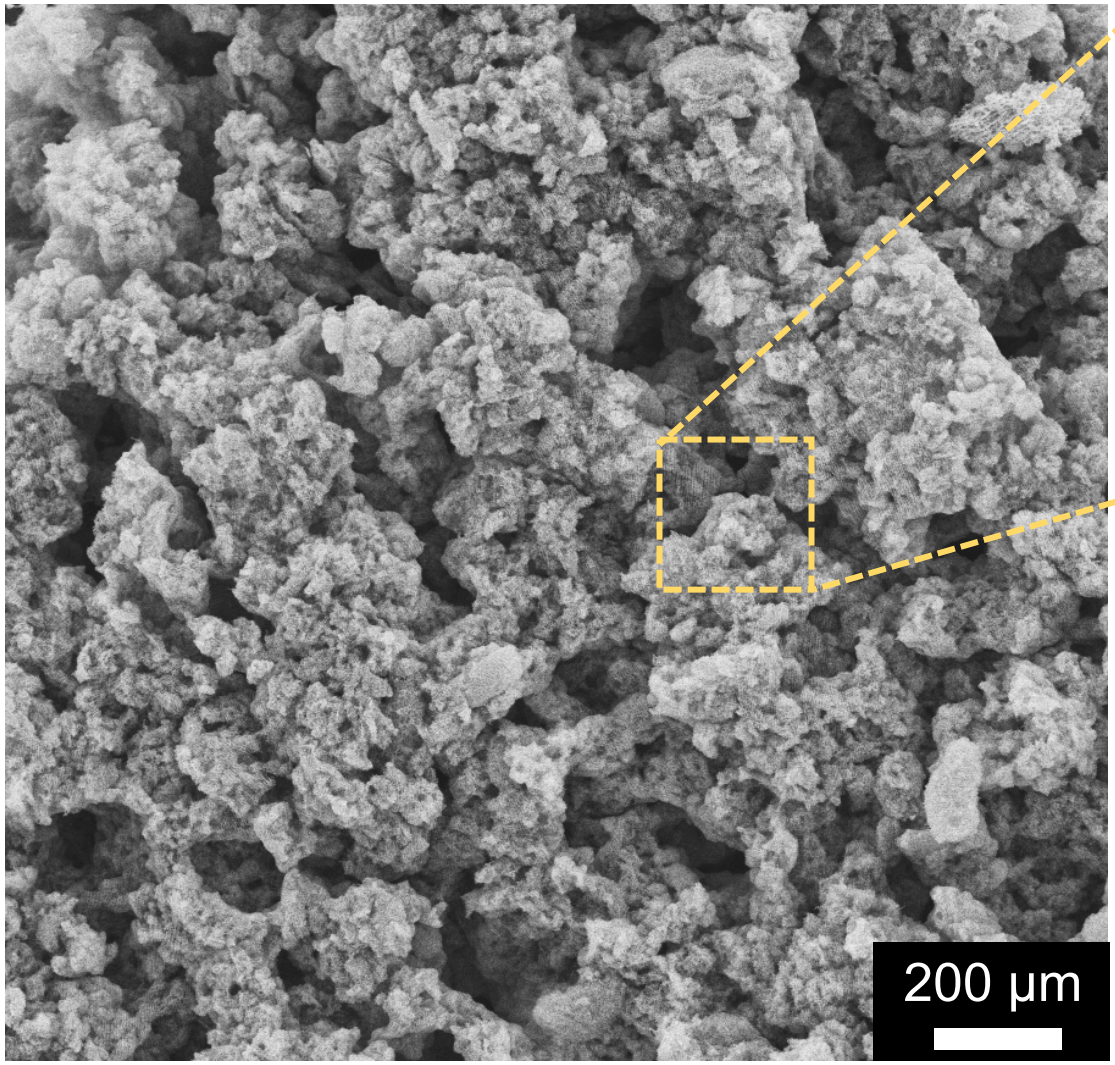


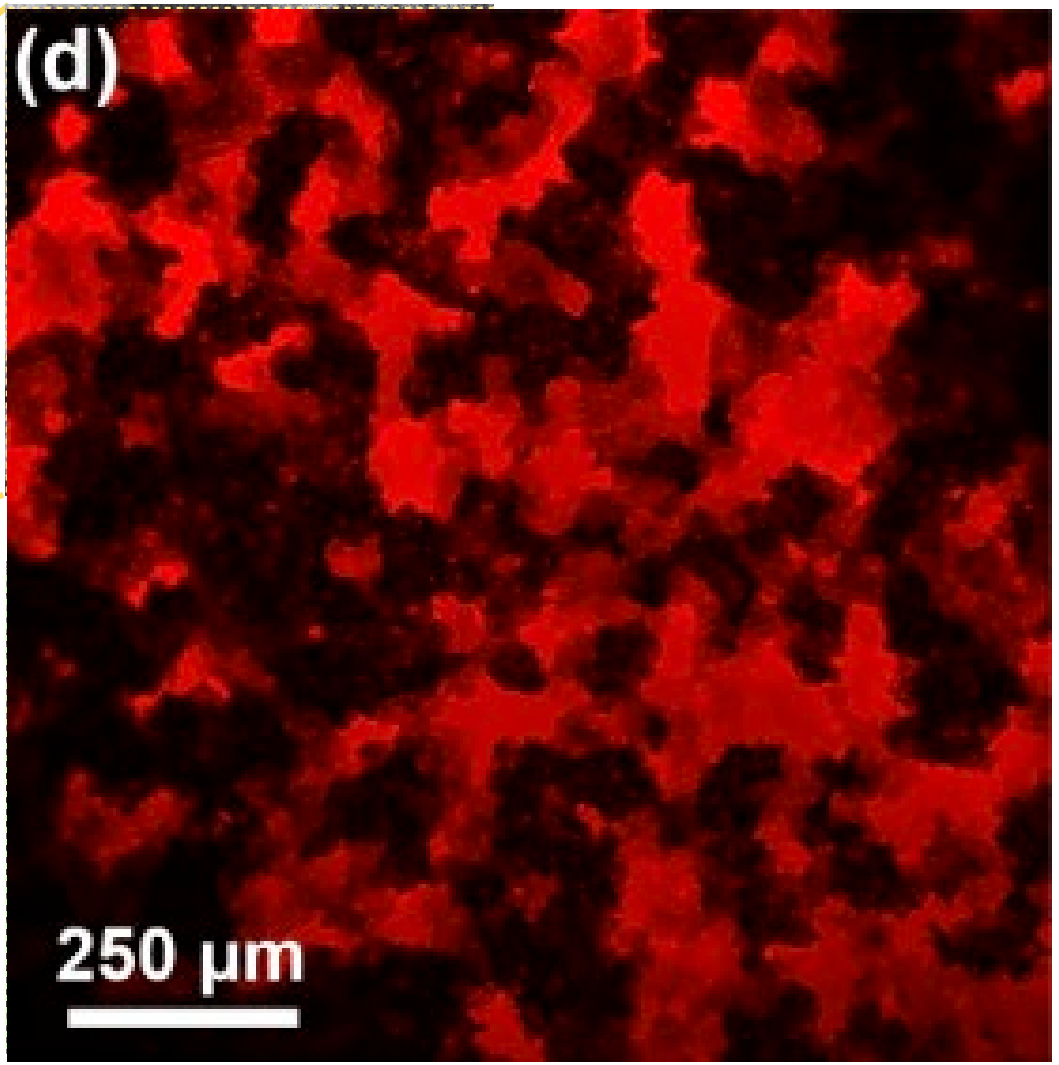




- Bicontinuous chitin cryogel was obtained by direct freeze-drying.

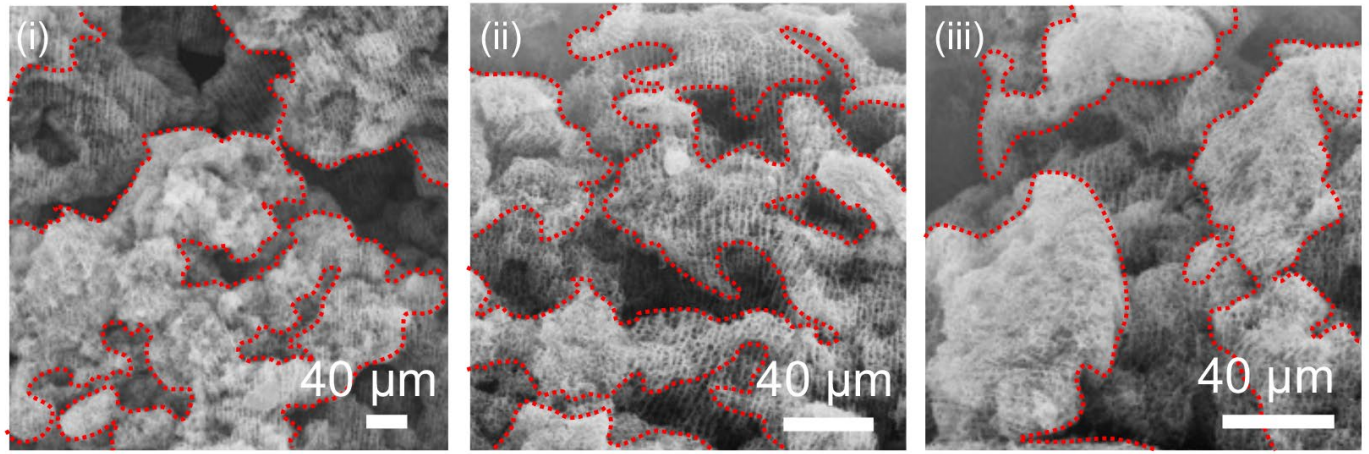
Chitin cryogel replicate the morphology of its emulsion template



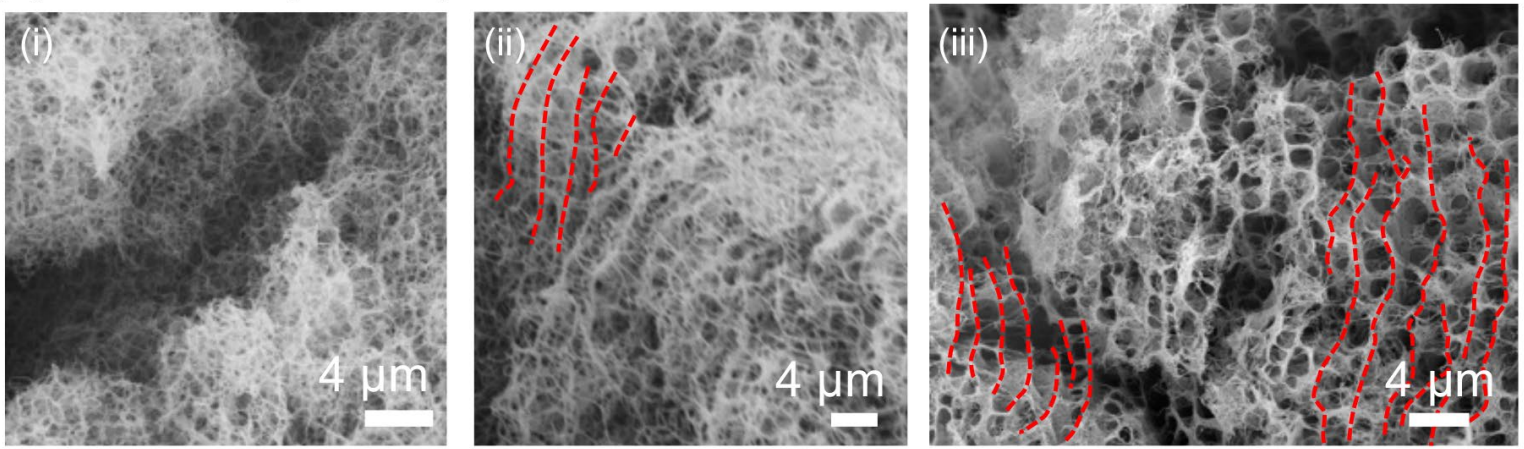


Two different void structures in the cryogel

(a) Luditine-templated channels



(b) Water-templated pores



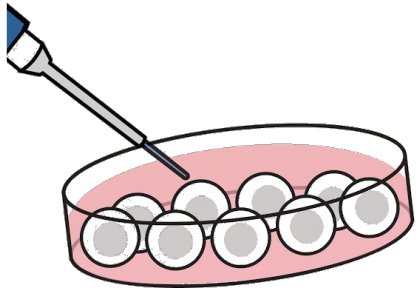
Amorphous structure

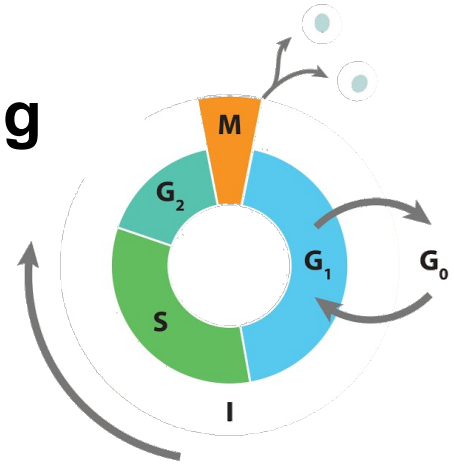
Mixed structure

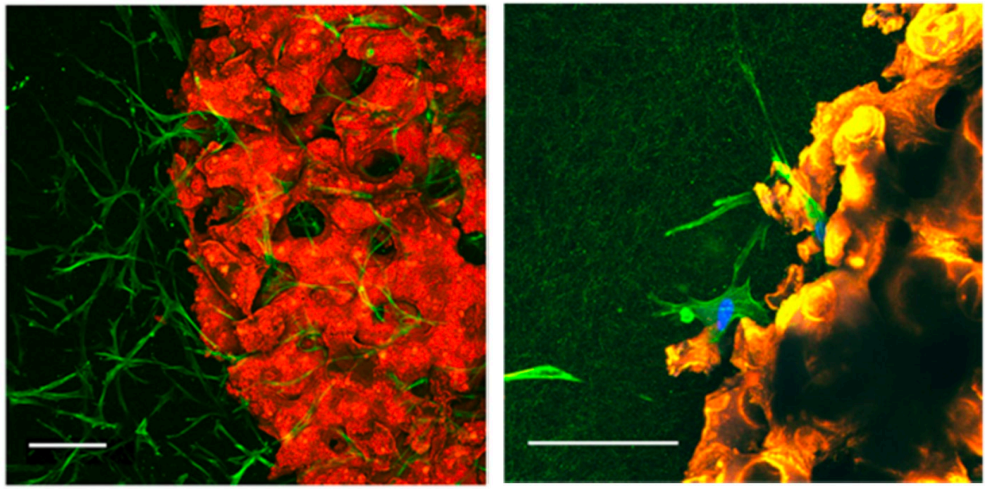
Aligned structure

Down the road — Potential applications

- **Cell culturing**

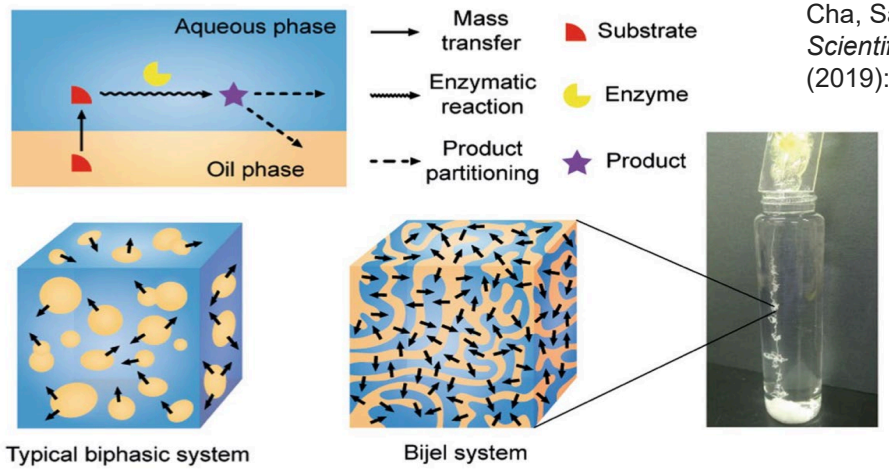






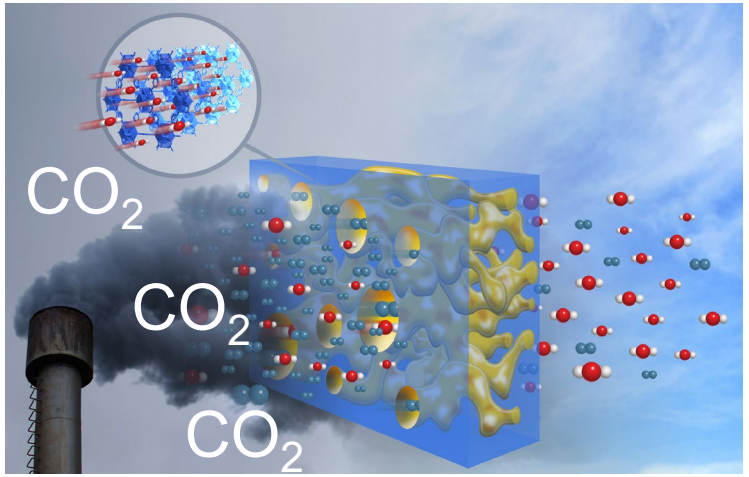
[1] Thorson, Todd J., Elliot L. Botvinick, and Ali Mohraz. ACS biomaterials science & engineering 4.2 (2018): 587-594.
[2] https://www.youtube.com/watch?v=RpDke-Sadzo

- **Micro-reactor**



Cha, Sanghak, et al. *Scientific reports* 9.1 (2019): 1-6.

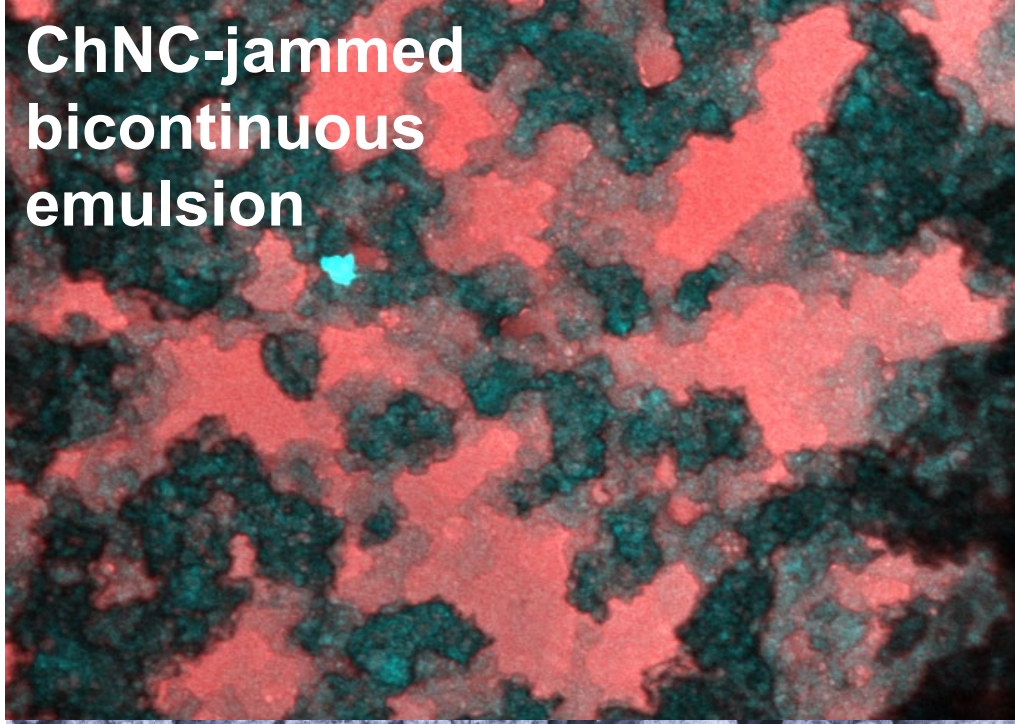
- **Gas sorption**

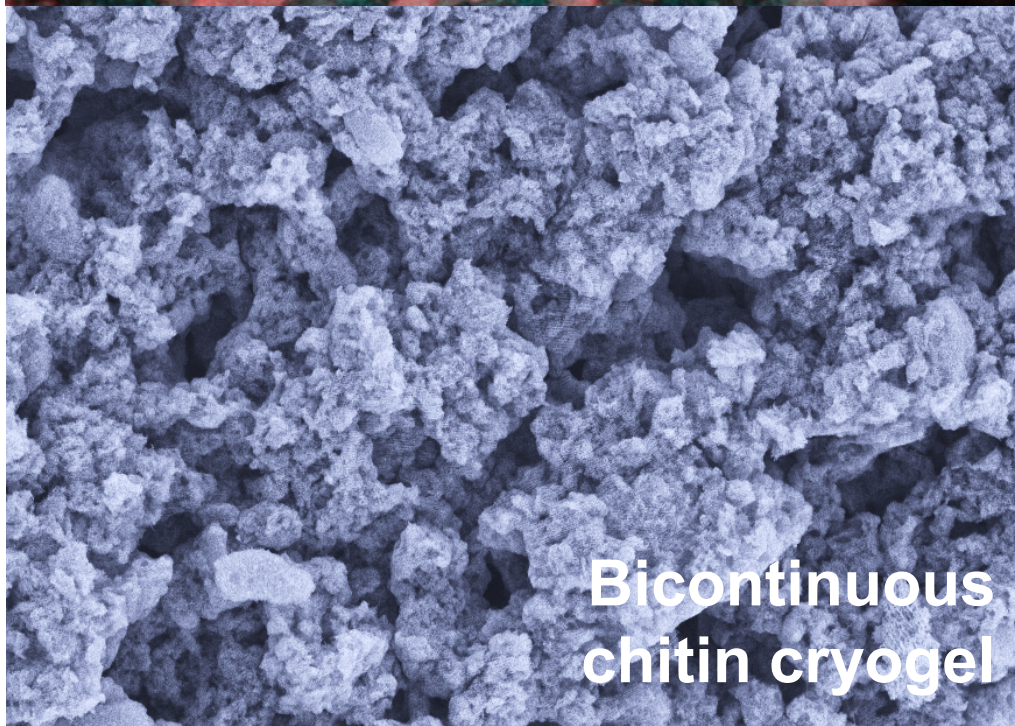


https://newscenter.lbl.gov/2016/03/17/carbon-capture-membrane/

Conclusion

- Bicontinuous emulsion was generated *via* intra-phase jamming of chitin nanocrystals (ChNCs);
- Bicontinuous chitin cryogel could be templated from bicontinuous emulsion, with a dual-sized pore structure;
- These bicontinuous materials have great potentials in the fields of :
  - Cell culturing;
  - Catalysis;
  - Gas sorption





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The University of British Columbia

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BioProducts Institute

BiCMat

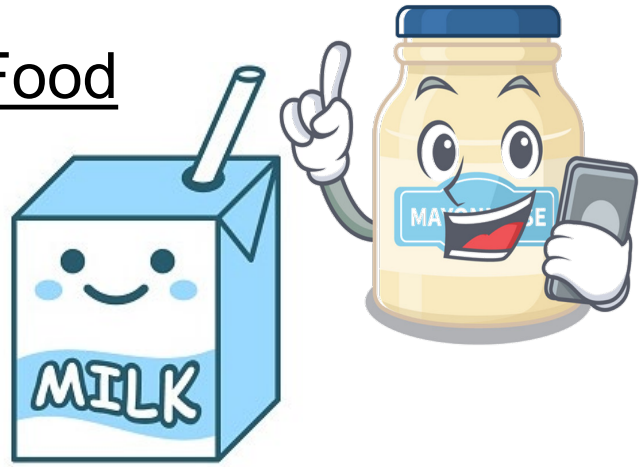
Thank you!

TAPPI NANO DIVISION

UBC

Emulsions

Food

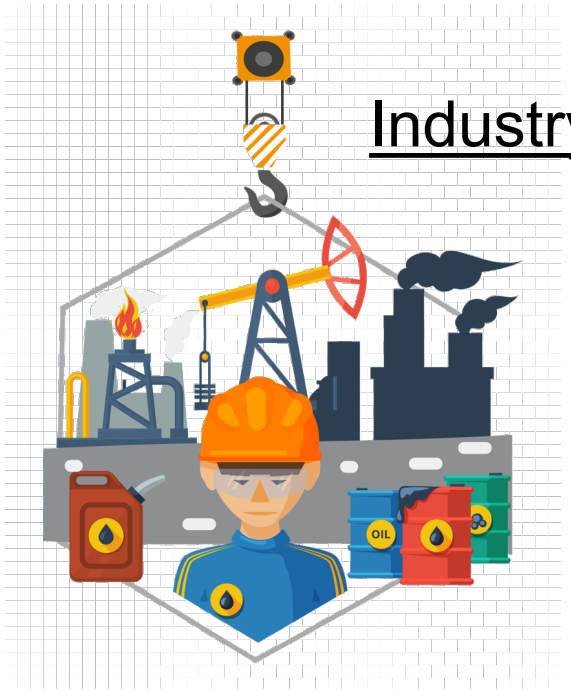


Cosmetic

Personal care

Health

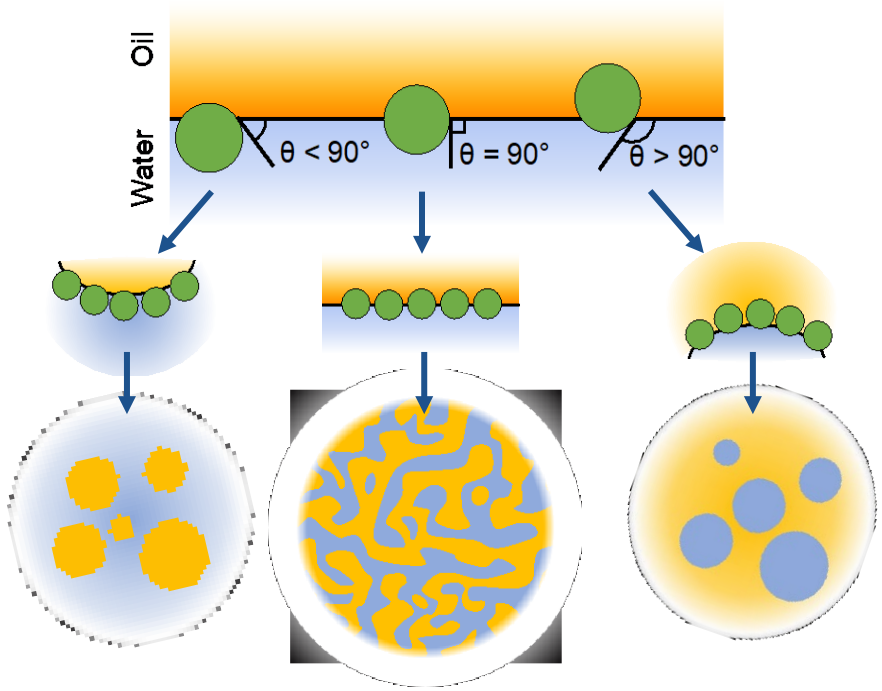
Industry

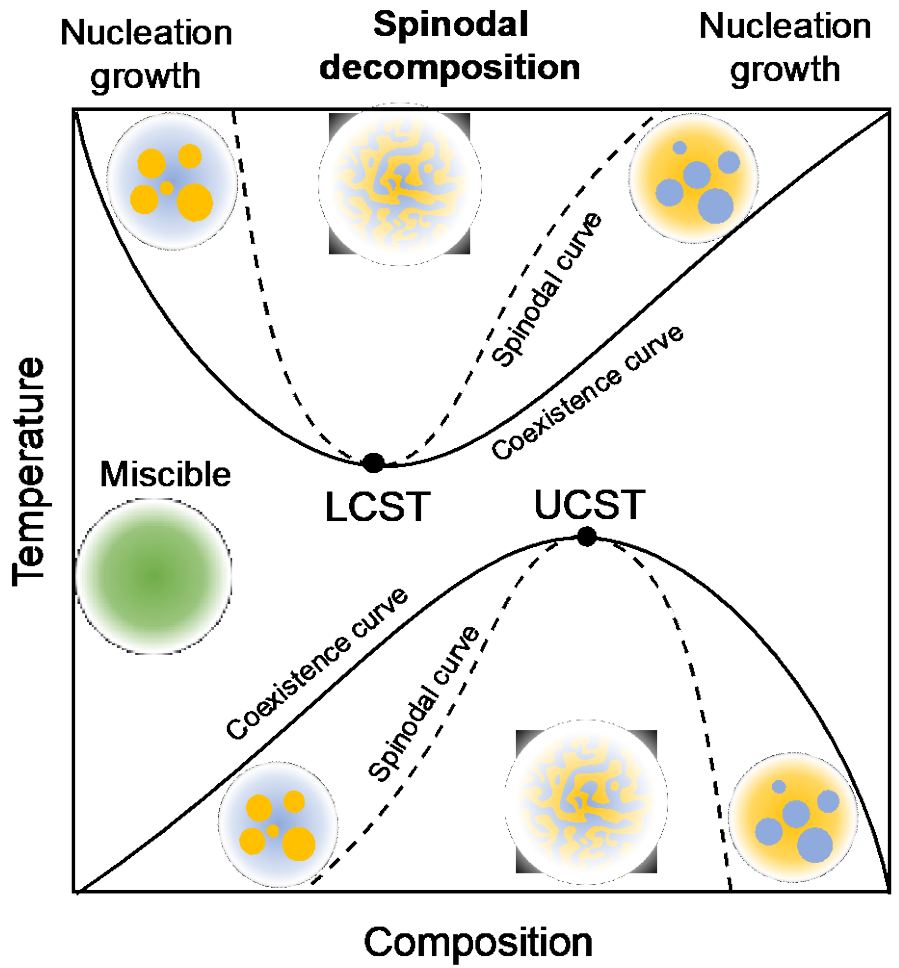


Images from Internet:
https://www.istockphoto.com/
https://www.pinterest.ca/
https://vhv.rs
Ashaolu, T.J., Environmental Chemistry Letters volume 19, pages3381–3395 (2021)

Principles for making bicontinuous Pickering emulsion

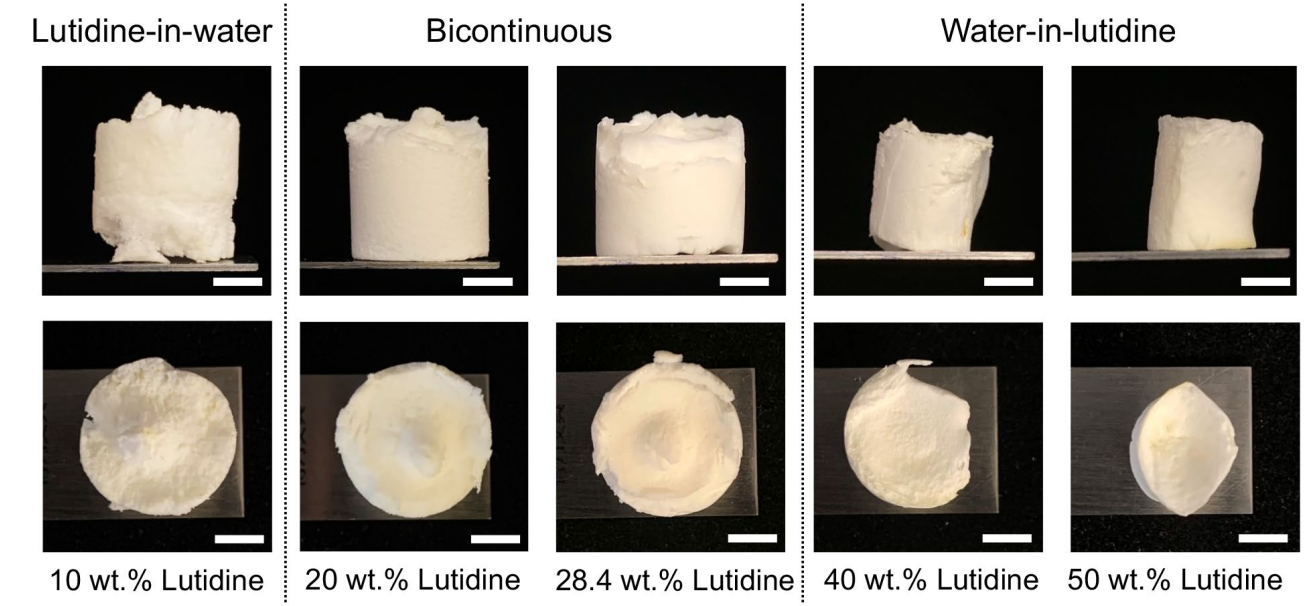
1. Choose the two phases;
2. Phase diagram;
3. Phase composition;
4. Particle wettability…

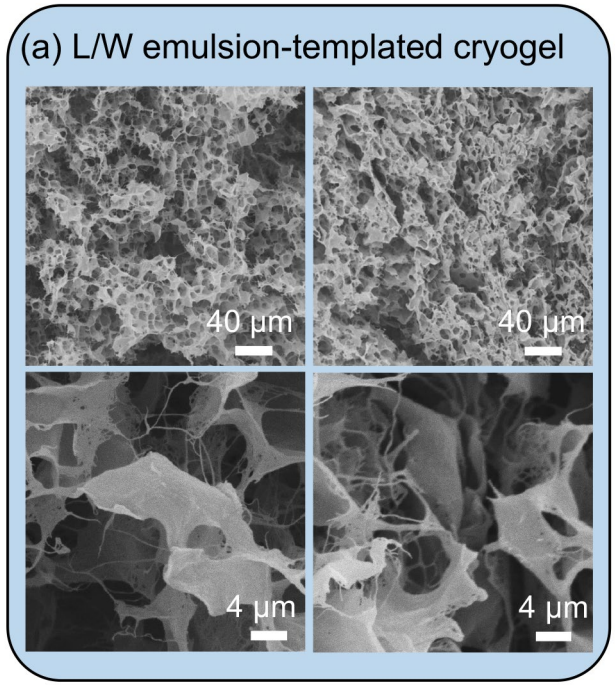


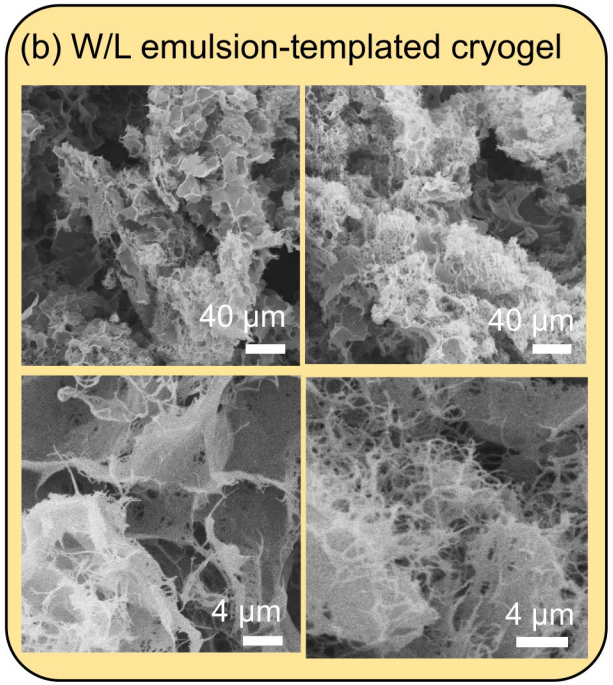


LCST: Lower critical solution temperature

UCST: Upper critical solution temperature


Lutidine-in-water
Bicontinuous
Water-in-lutidine
10 wt.% Lutidine
20 wt.% Lutidine
28.4 wt.% Lutidine
40 wt.% Lutidine
50 wt.% Lutidine


(a) L/W emulsion-templated cryogel
40 μm
40 μm
4 μm
4 μm


(b) W/L emulsion-templated cryogel
40 μm
40 μm
4 μm
4 μm