Using micromanipulation to study arrested coalescence of fat globules

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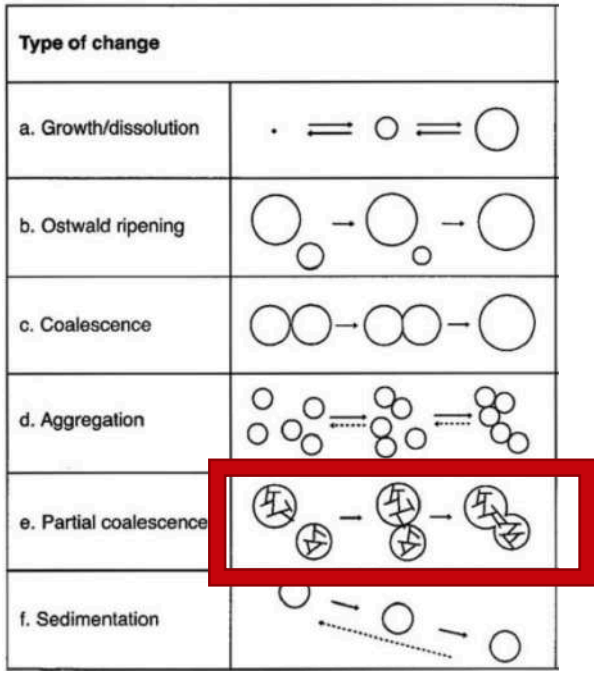
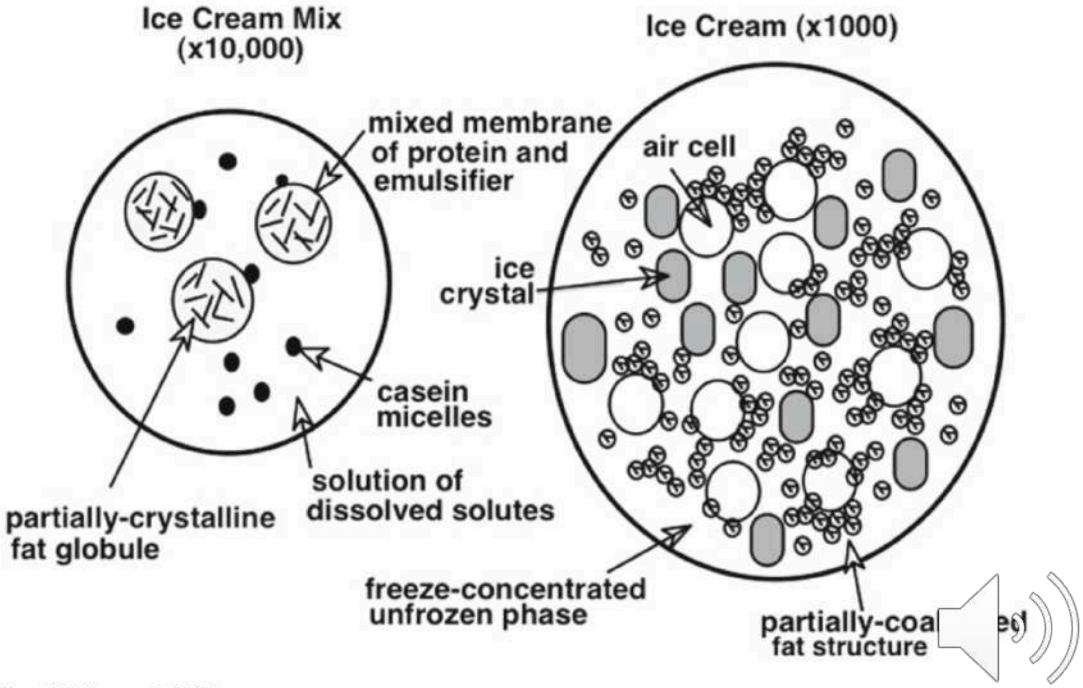
Background- Partial (Arrested) Coalescence

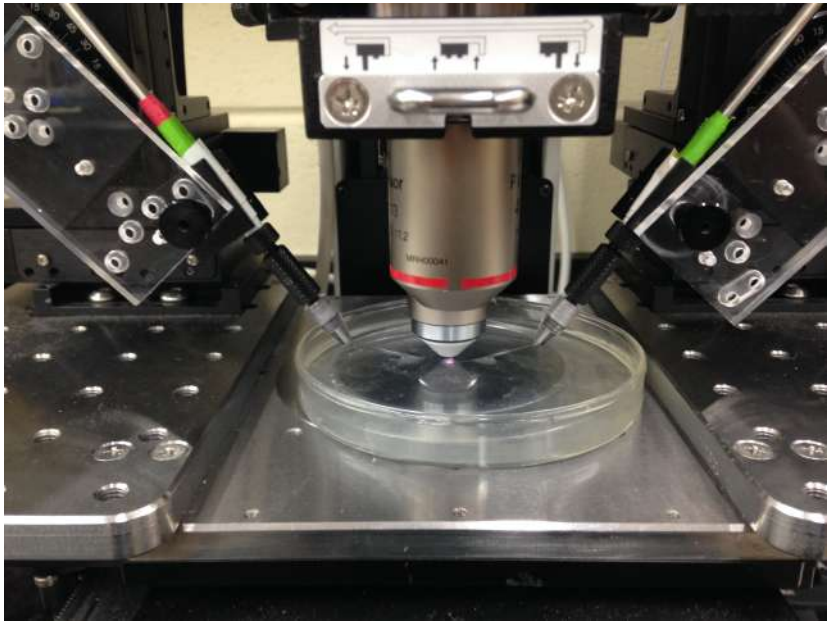
- Destabilization in oil-in-water emulsions
- Incomplete separation of lipid globules
  - Halted by internal solid fat network or particles at the interface
- Important for structure of ice cream and whipped toppings

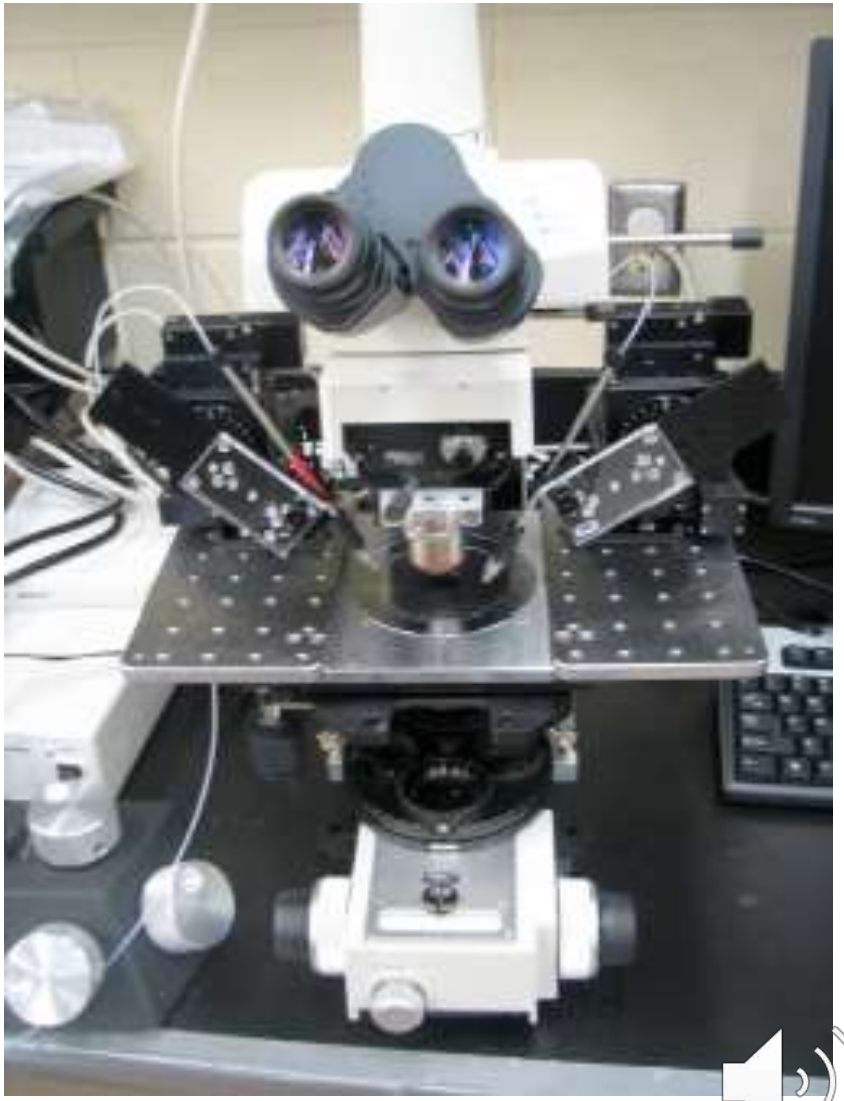




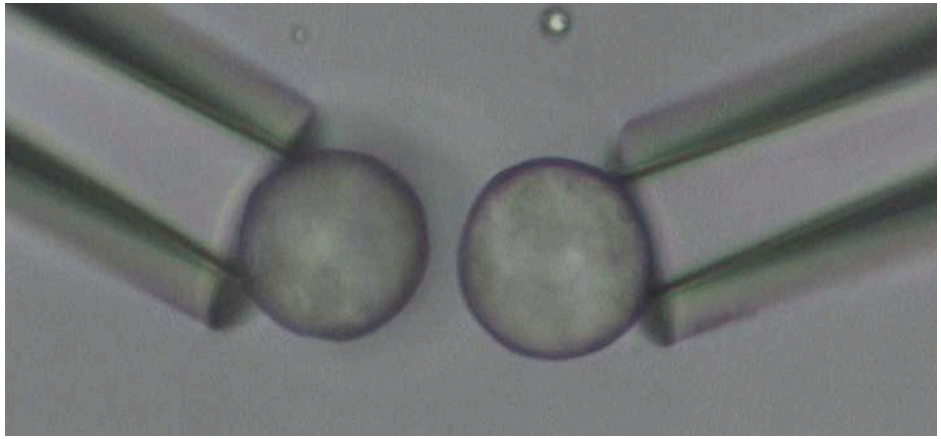
Summary of destabilization mechanisms in emulsions (after Walstra, 2003).

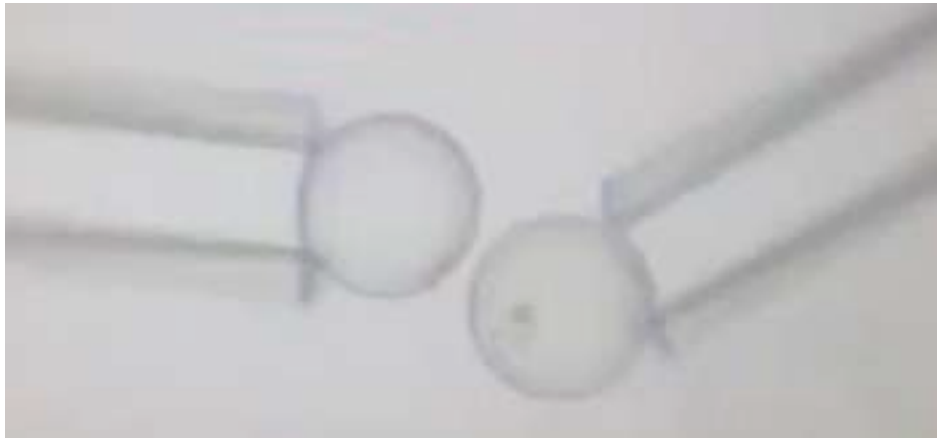
Micromanipulation





Flexibility with Micromanipulation





Measuring Coalescence

Strain $\varepsilon = 1 - [L_T/(L_1 + L_2)]$

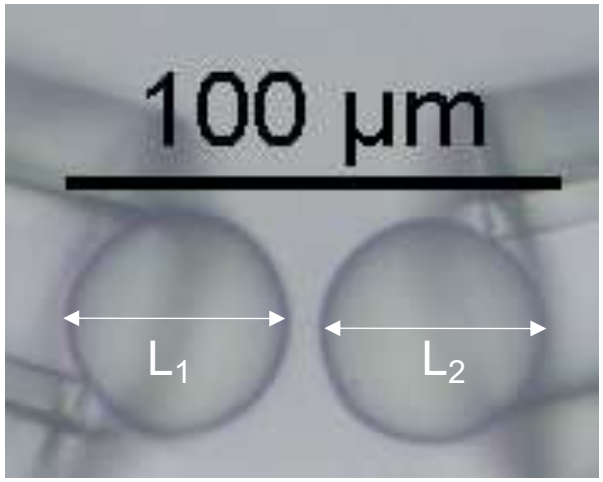
L_1 and L_2= diameter of droplets

L_T=length of coalesced structure

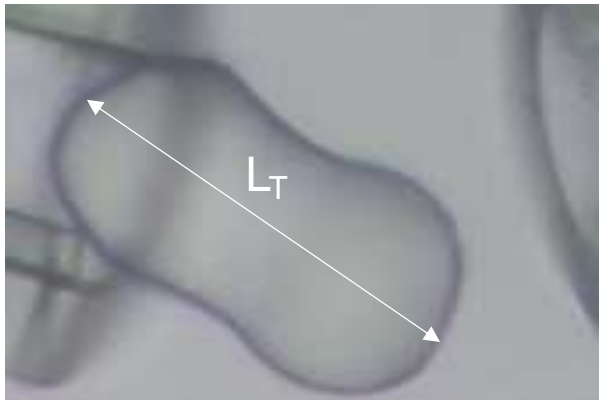
ε=0 is total stability

ε=0.37 is full coalescence

Before



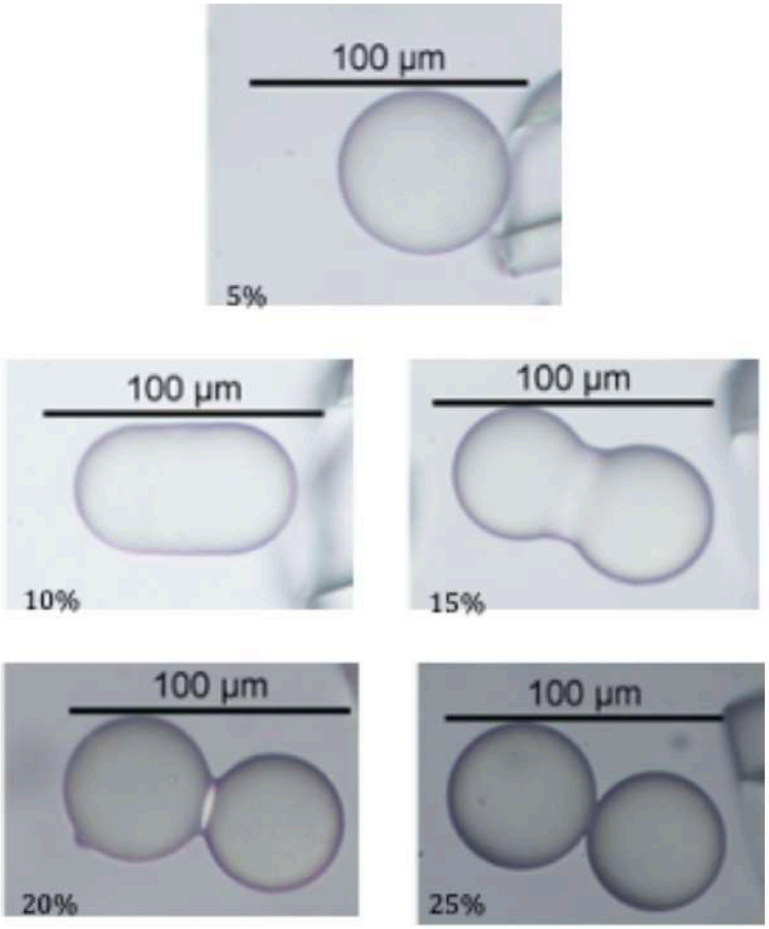
After



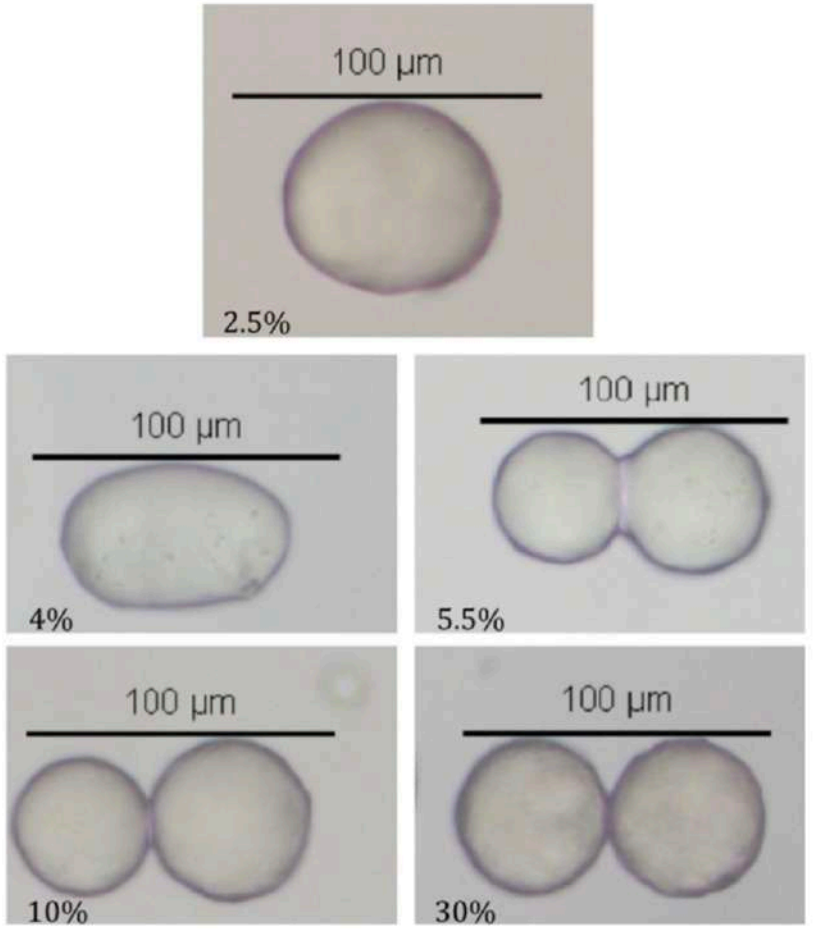
Allows us to study factors:

1. Solid fat content
2. Droplet size
3. Interfacial fat crystals
4. Thickeners
5. Emulsifiers

1. Solid Fat Content



Tristearin in triolein

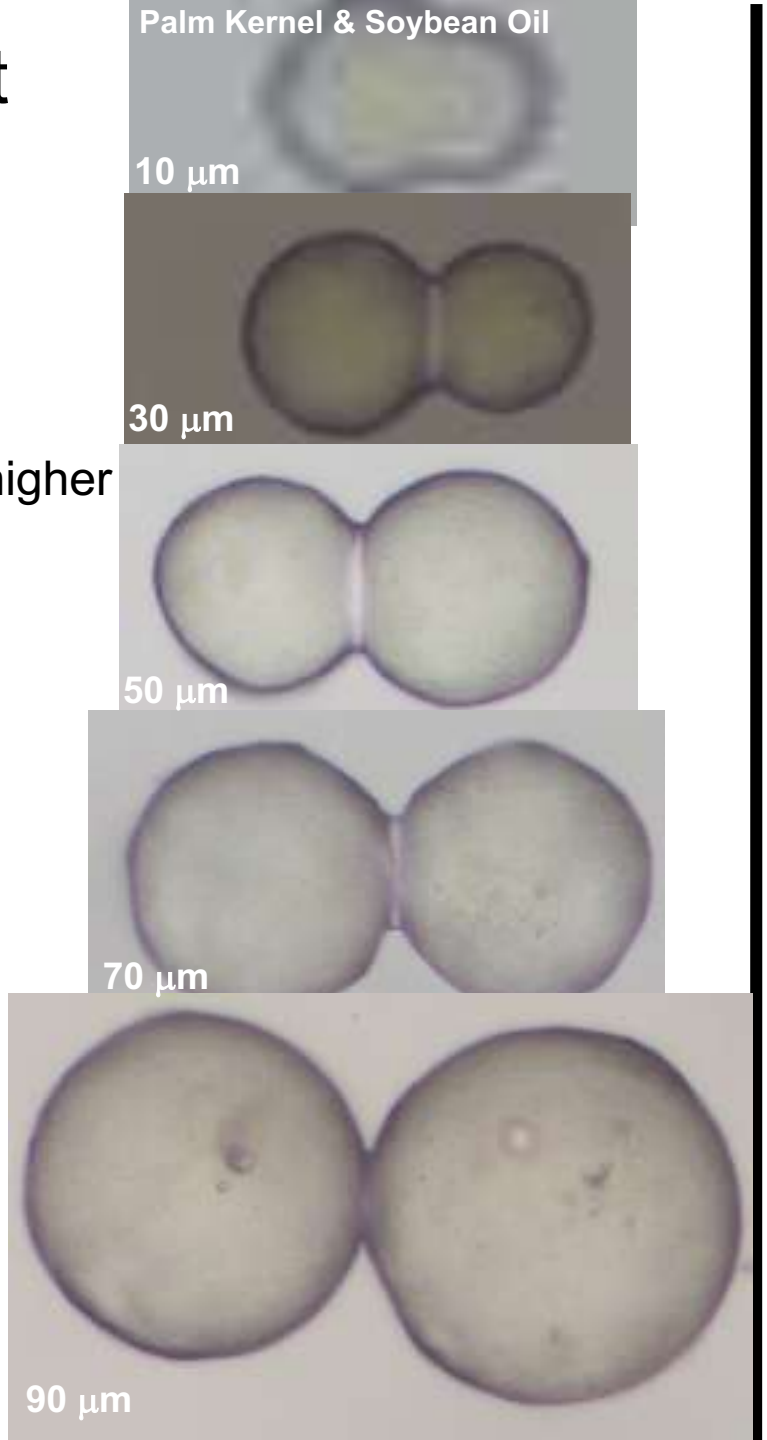


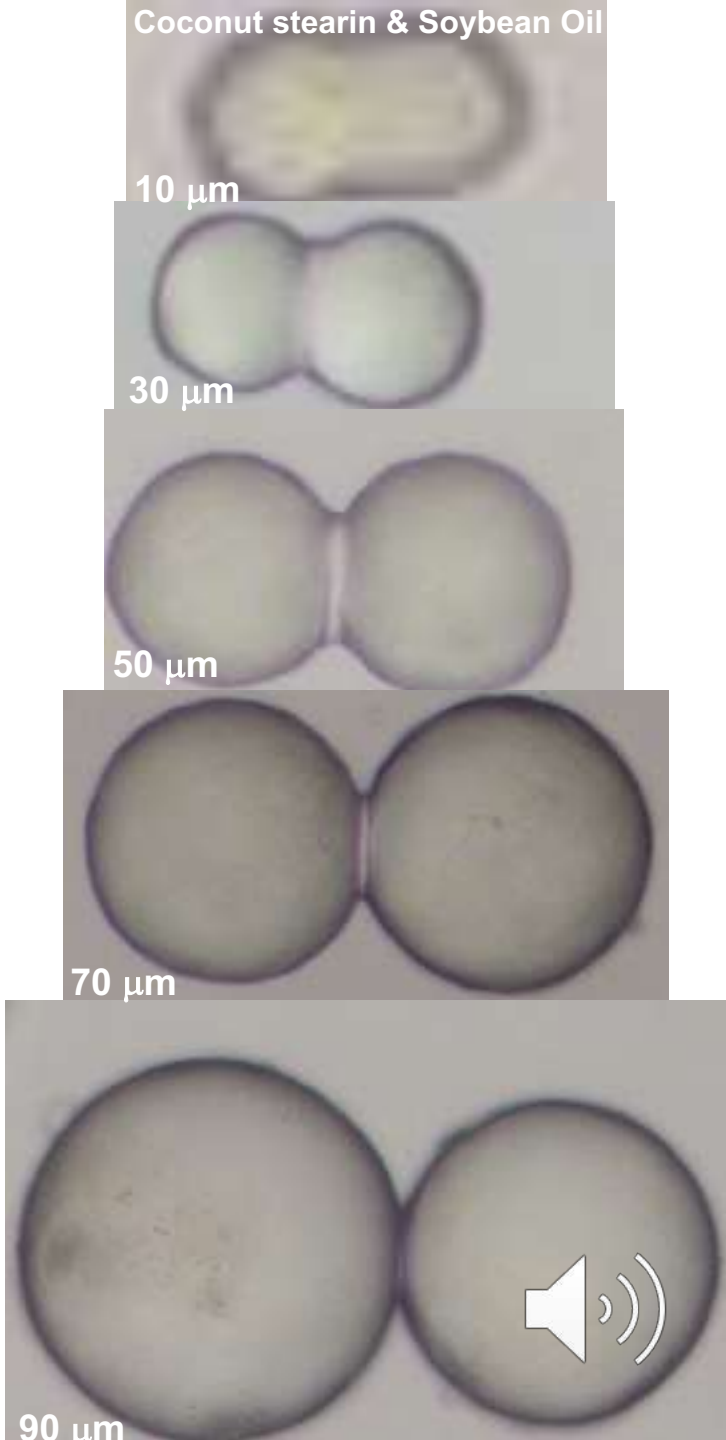
Coconut stearin in soybean oil

2. Droplet Size

- Smaller droplets=higher internal pressure

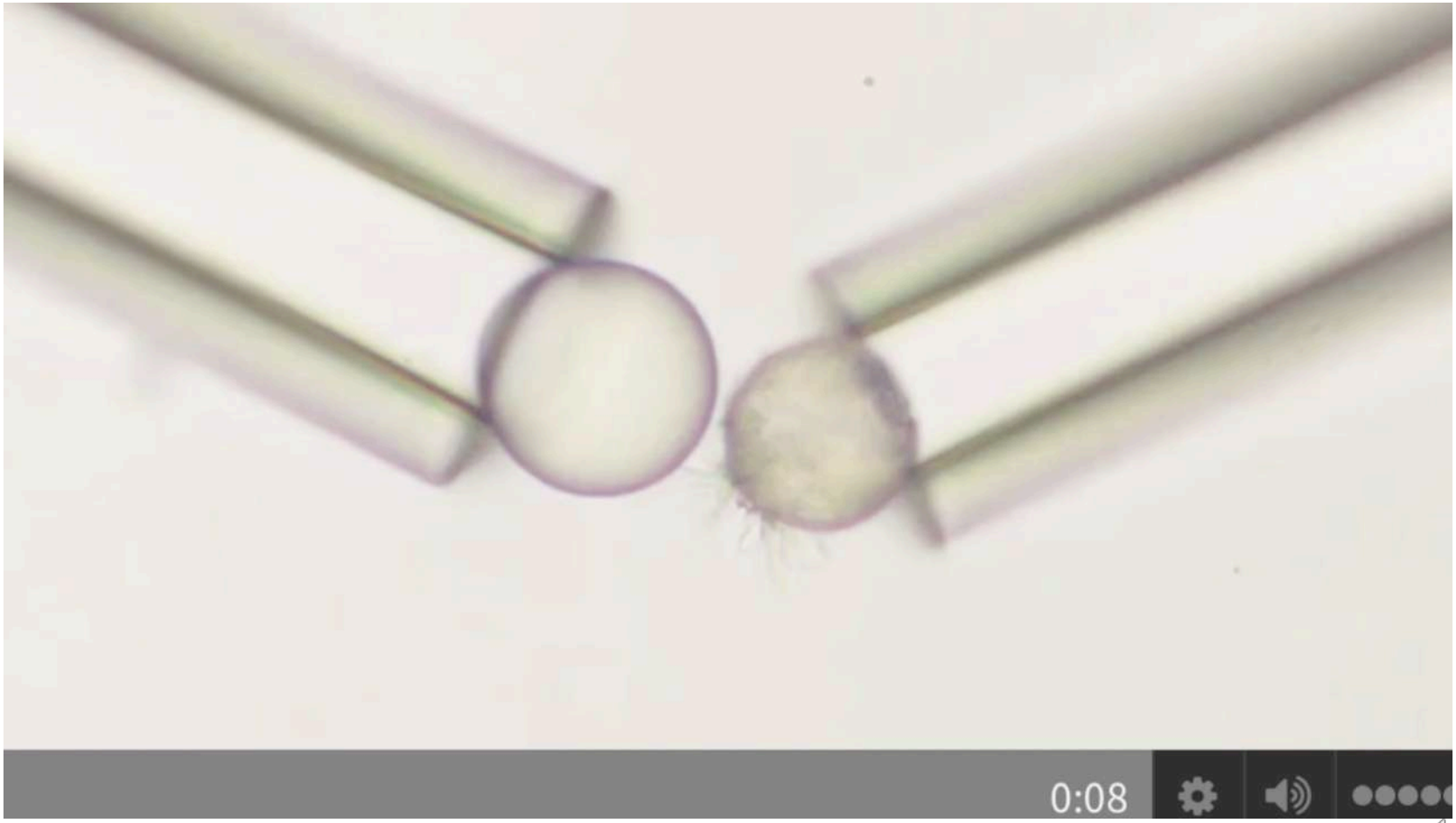
$$\Delta P = \gamma \frac{2}{R}$$



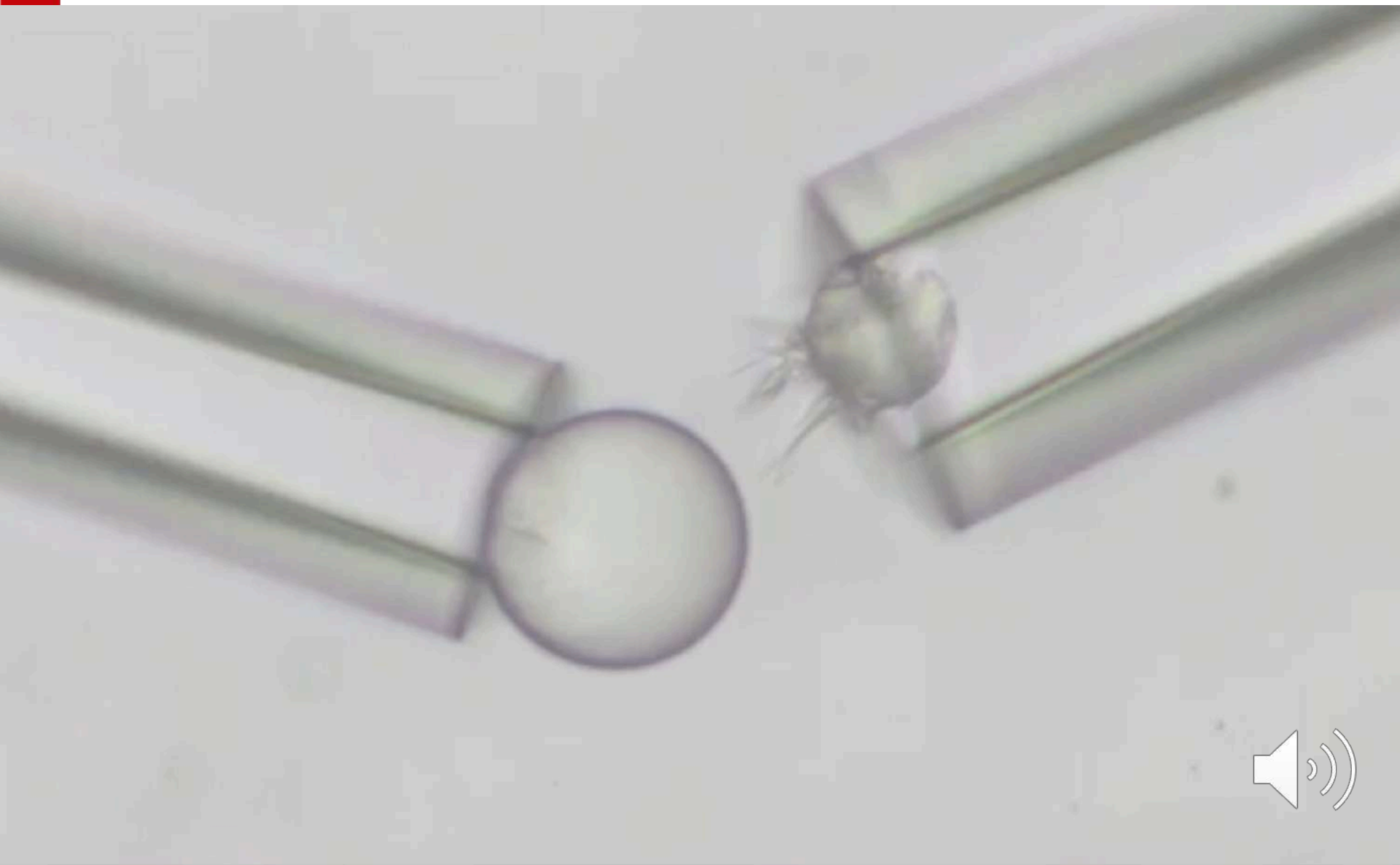


3. Interfacial Crystals

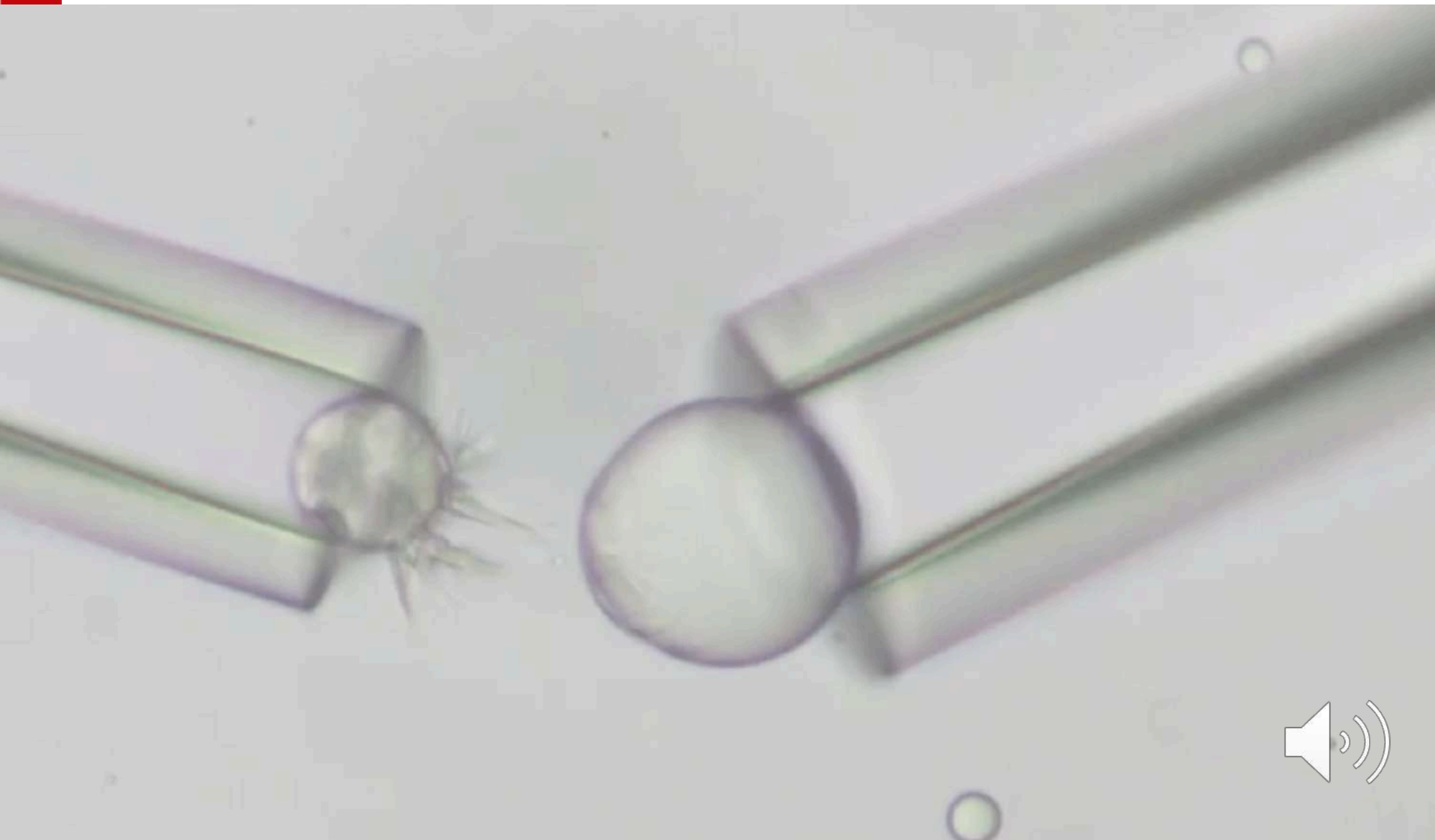
Soybean oil drop (left) 100% PKO drop (right)



Probing liquid side of droplet

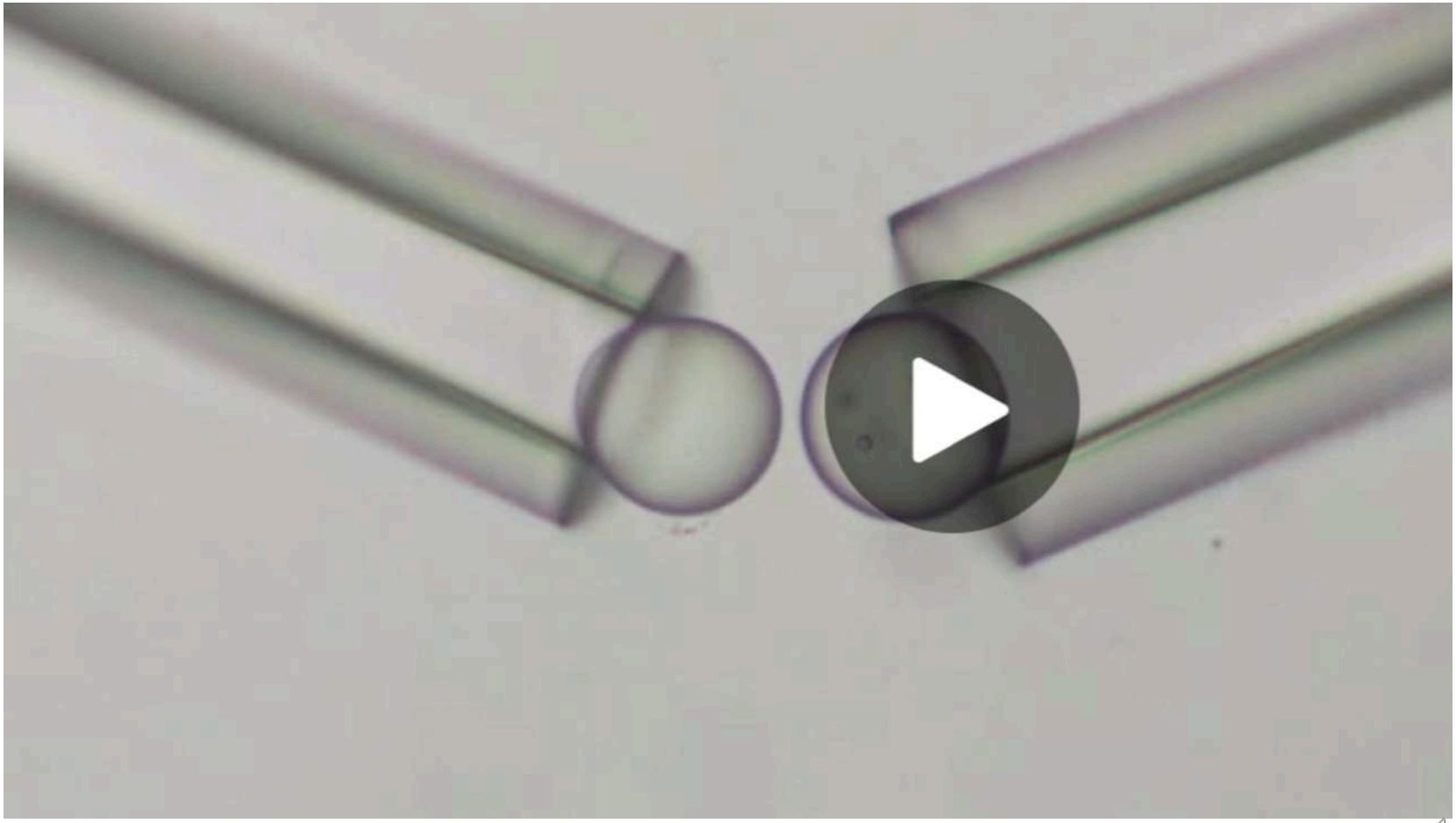


Probing crystalline side of droplet

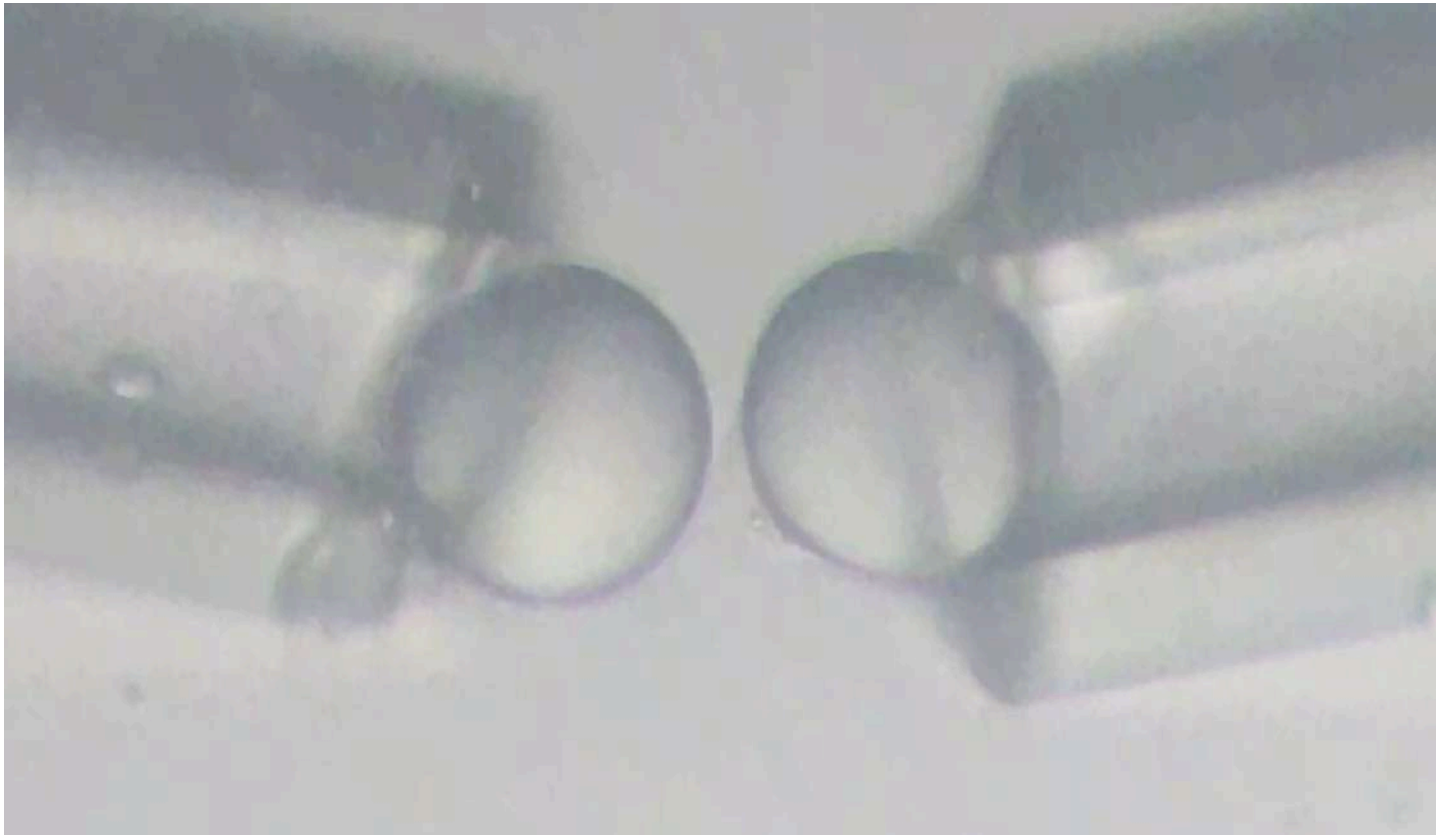


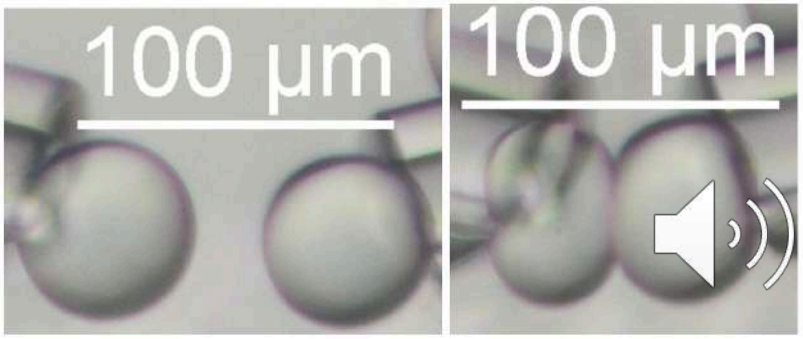
4. Thickeners

Soybean oil droplets with methylcellulose coating



Protein inhibits coalescence

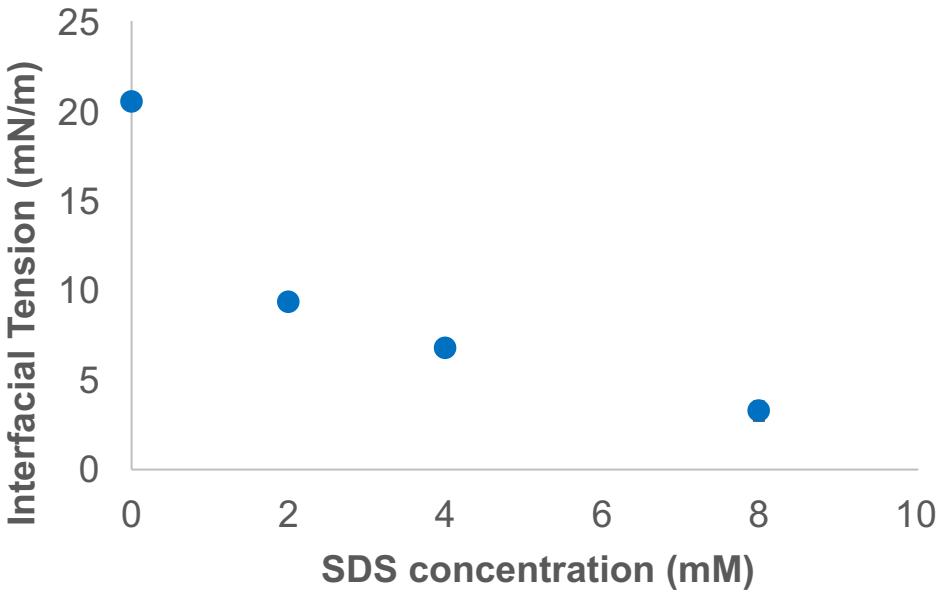


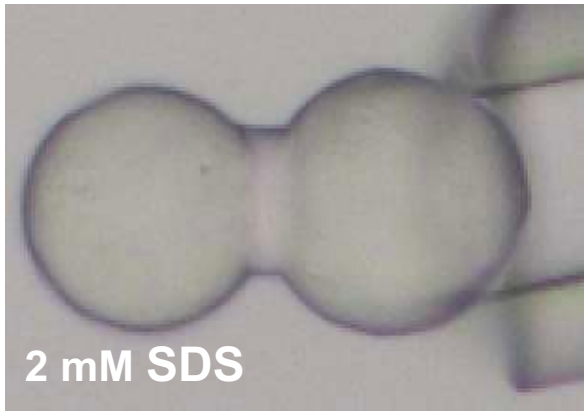


5. Emulsifiers

Sodium dodecyl sulfate (SDS)

- Range of interfacial tension achieved for different [SDS]
- No trend observed for strain





Mono/diglycerides + Polysorbate 80

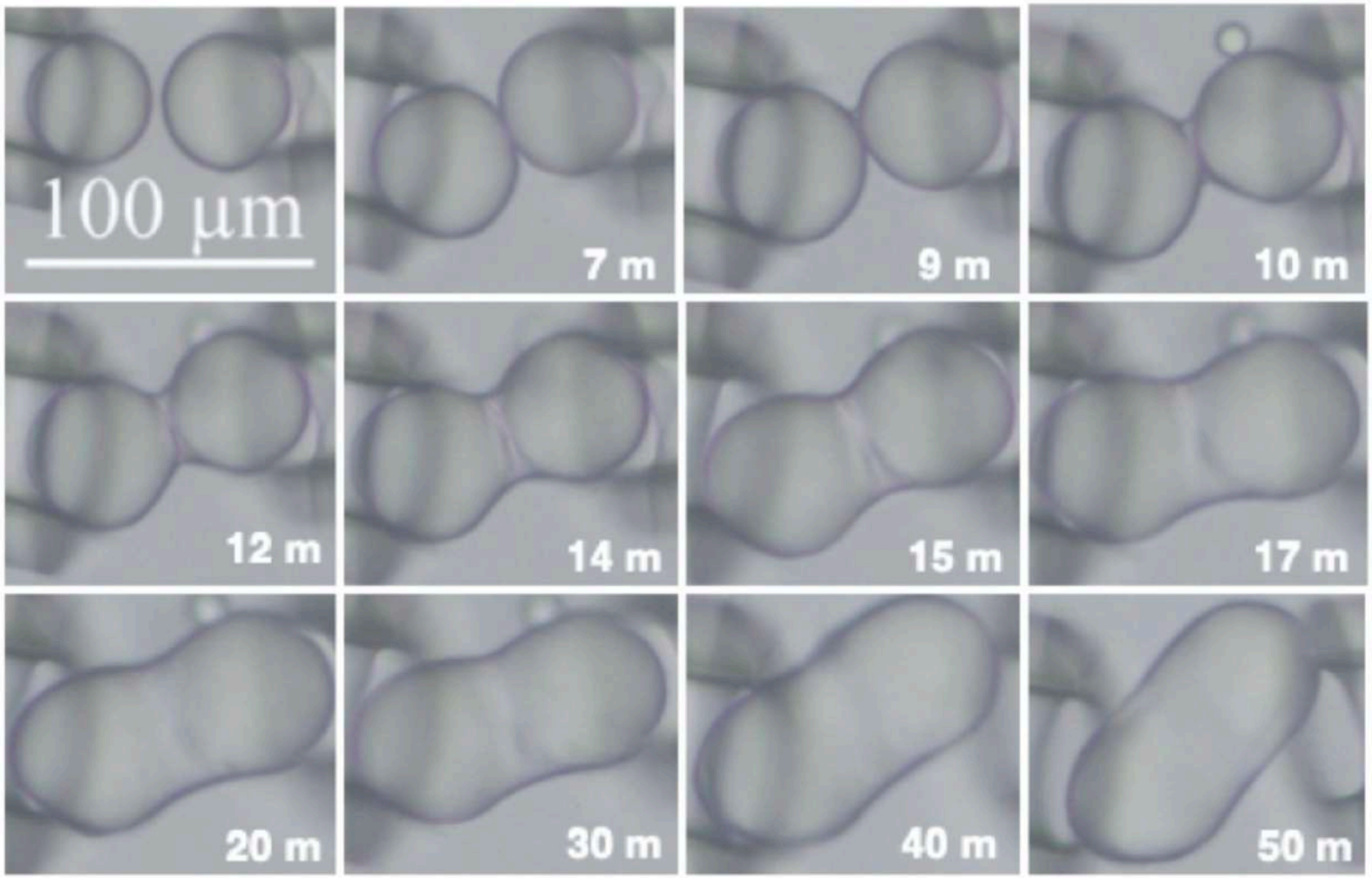


Figure 4.1 Coalescence recorded over time for two 2.5% solid fat content anhydrous milk fat droplets in the presence of 90:10 mono/ diglycerides:polysorbate 80 and 2.5% protein. Coalescence begins through a small oil neck that can be observed at minute nine and shape relaxation proceeds to the fiftieth minute.

Coalescence Time

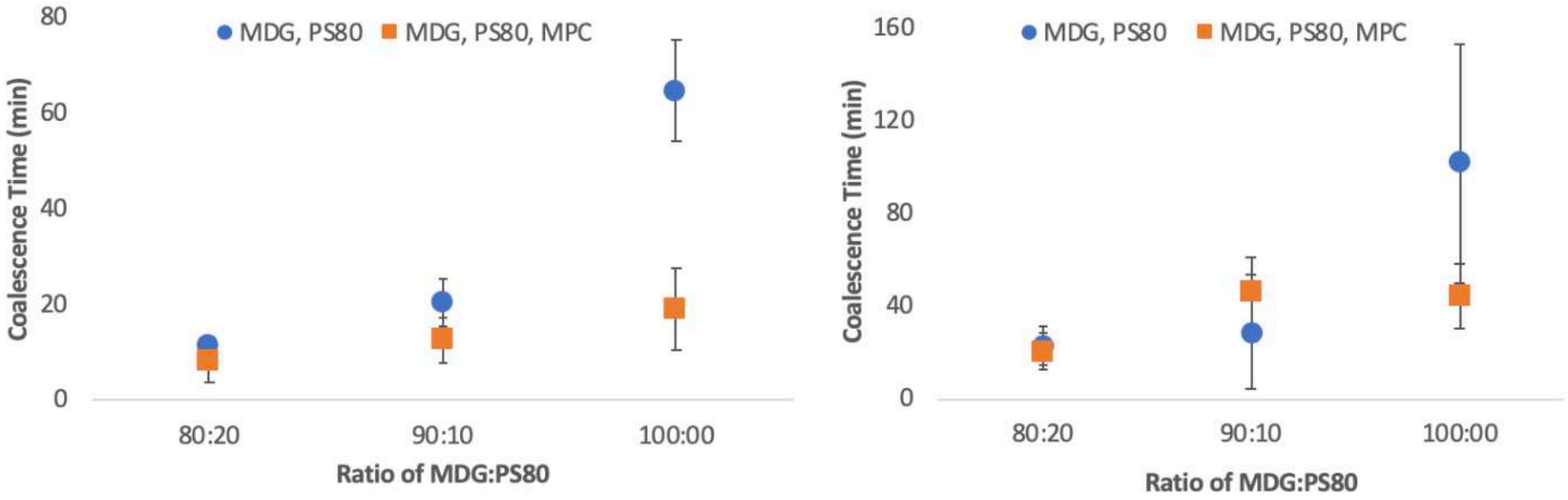


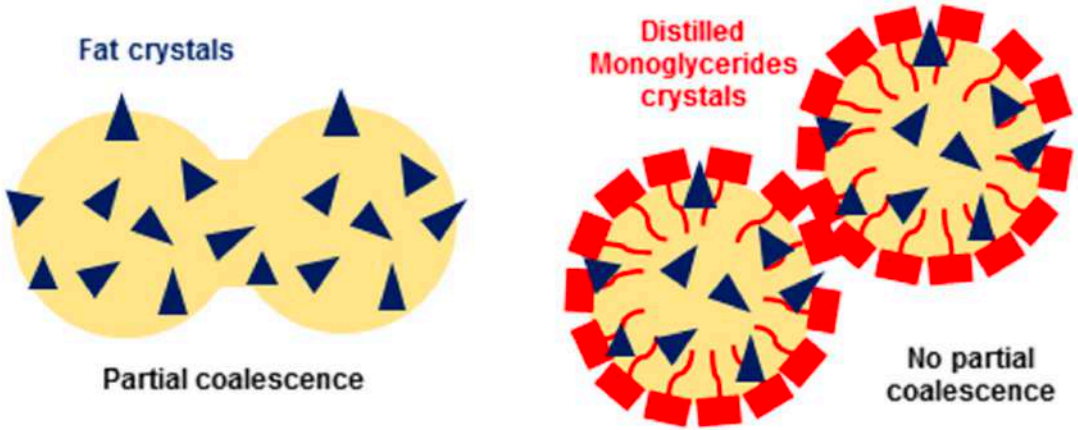
Figure 4.11 Coalescence time as a function of different ratios of mono/diglycerides:polysorbate 80 (MDG:PS80) with and without milk protein concentrate (MPC). In general, the time of coalescence tends to be elongated at the amount of MDG is increased for both fat systems. **(left)** palm kernel oil/ soybean oil (PKO/SO) results **(right)** anhydrous milk fat (AMF) results

Increasing mono/diglycerides

- Lowers strain
- Increases coalescence time

Why?

- Crystallizing at interface
  - Solid barrier
- Crystal promotor (chain crystallization)



From Goibier et al. (2017)

Conclusions

- Micromanipulation is a new method to study partial coalescence

1. ↑ solid fat content, ↓ strain
2. ↑ droplet size, ↓ strain
3. Interfacial fat crystals- can initiate coalescence
4. Thickeners- can inhibit coalescence
5. Emulsifiers- type matters