Ugelstad Laboratory

NTNU | Department of Chemical Engineering

Colloid and polymer chemistry

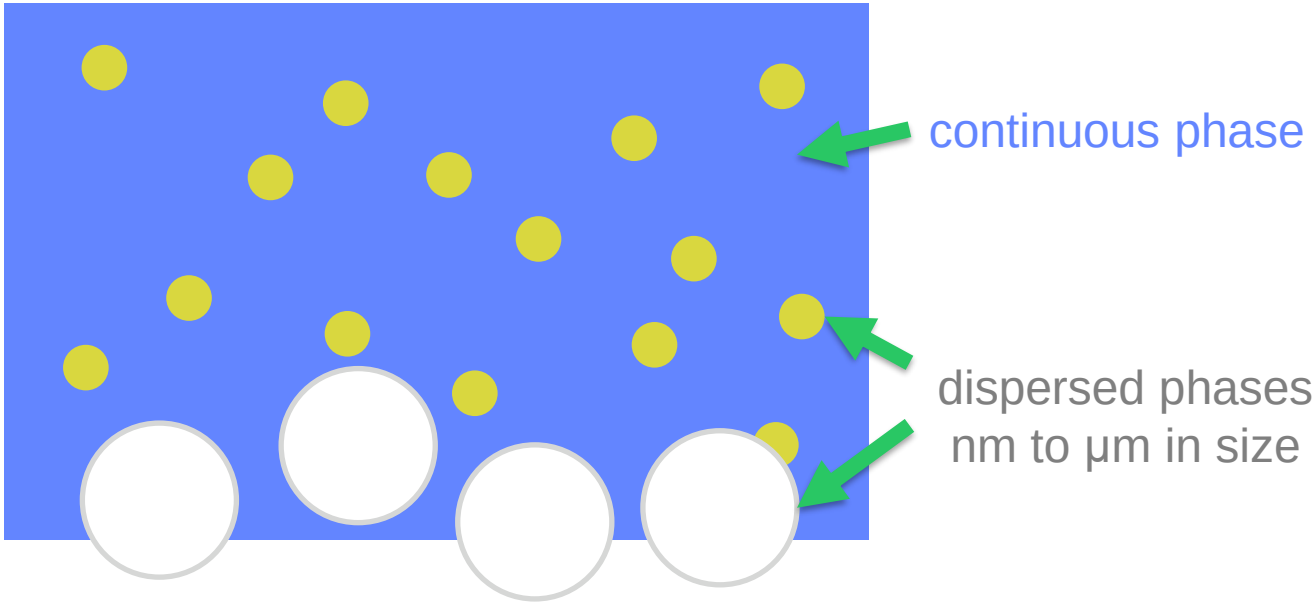
Nadia Shardt

Associate Professor

Ugelstad Laboratory

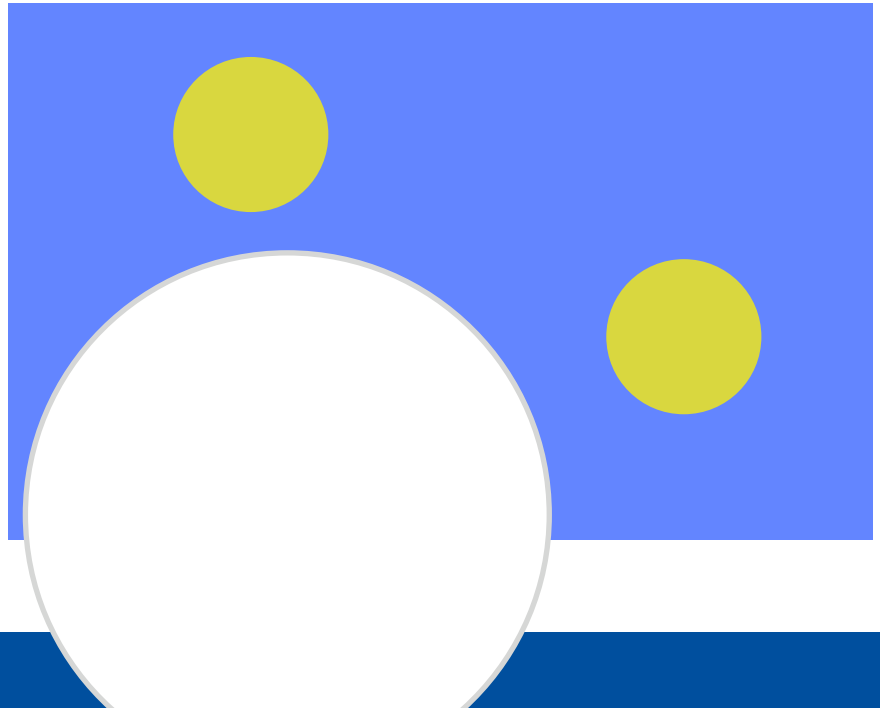
Colloid and polymer chemistry

- Colloids and dispersed systems: multiple phases



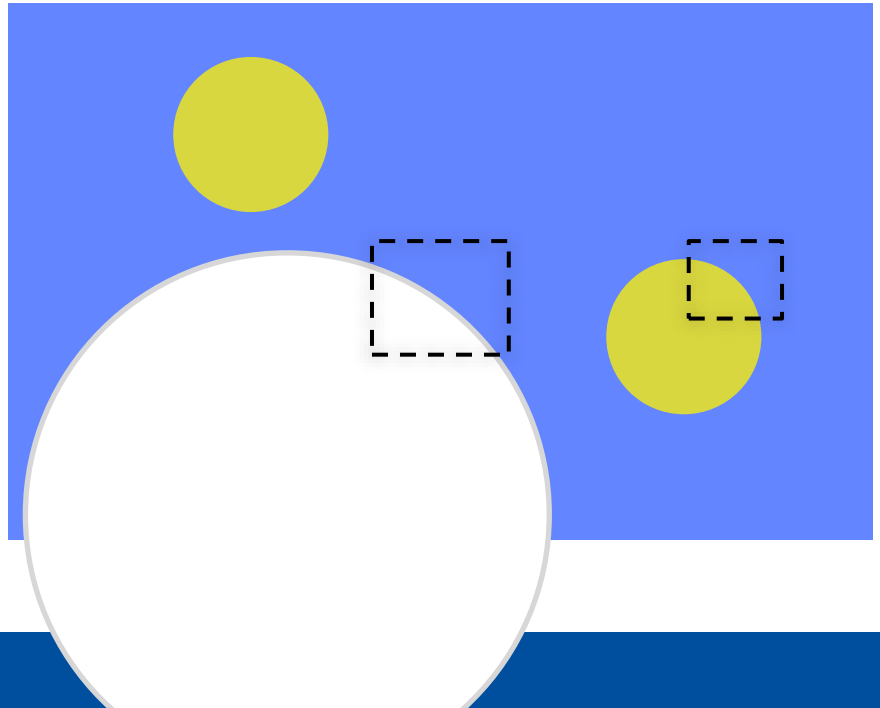
Colloid and polymer chemistry

- Colloids and dispersed systems: multiple phases



Colloid and polymer chemistry

- Colloids and dispersed systems: multiple phases



modify surface(s)
to promote
or inhibit interactions
between dispersed
phases

e.g., effect of
surfactants,
solid particles,
polymers, and
dissolved components

Colloid and polymer chemistry

- Colloids and dispersed systems: multiple phases






1. Where did we start?
2. Where are we today?
3. What's next?

Origin of Ugelstad Laboratory

- Group inaugurated by Johan Sjöblom in 2002

Establish new experimental and teaching facilities

Train students in the field of colloid and polymer chemistry

Collaborate closely with local and international industries

Exchange internationally

Images from Johan Sjöblom

Founding and affiliated members

ChevronTexaco Technology Company/Chevron Corporation

Aker Solutions

Champion Technologies/Nalco Champion

Papir og fiberinstituttet

Wärtsilä Oil and Gas Systems

REC Wafer

Borregaard Lignotech

Total

Statoil/Equinor

Shell Technology Norway

Vetco

SINTEF Energiforskning

Norsk Hydro

Aibel Technology

Du Pont de Nemours International

Institutt for Energiteknikk

KSV Instruments

Emery Oleochemicals

Akzo Nobel Surface Chemistry

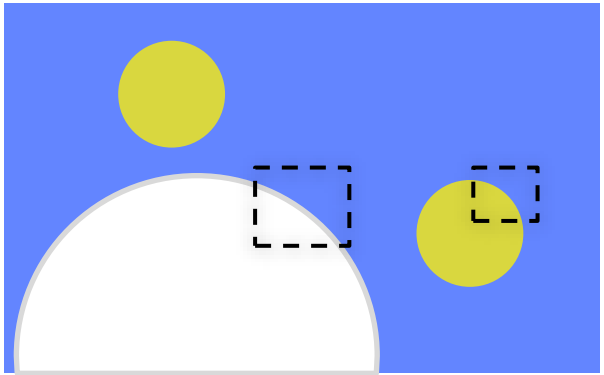
Hamworthy

10 years later

Ugelstad 10th Year Anniversary, September 13th, 2012
Trondheim, Norway

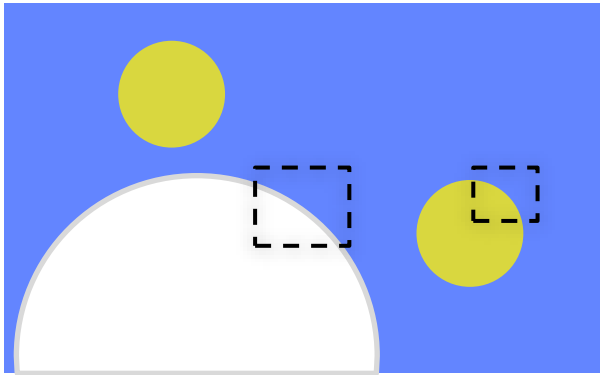
10 years later

- Further investments in experimental facilities



10 years later

- Further investments in experimental facilities



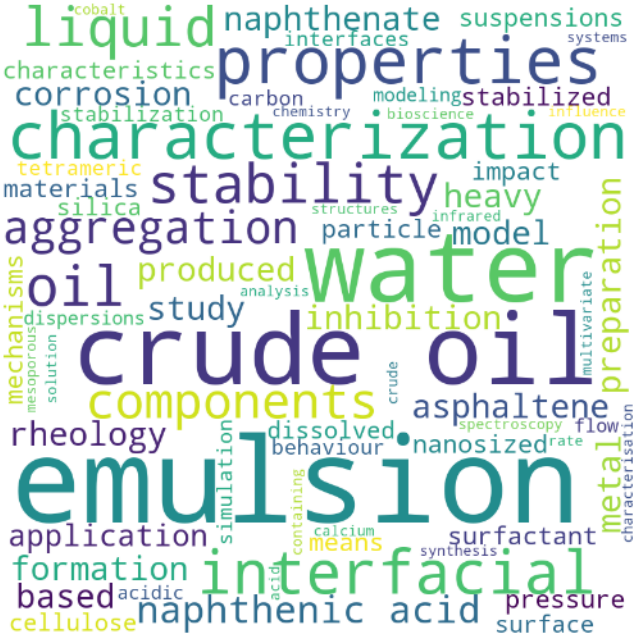
Measure
interfacial properties
sizes of dispersed phases

Observe
coalescence or stability
nucleation and crystallization
flow in porous media

Design
new materials, e.g., porous
new processes

10 years later

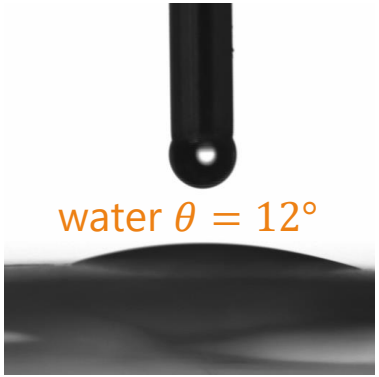
- Students trained in colloid and polymer chemistry

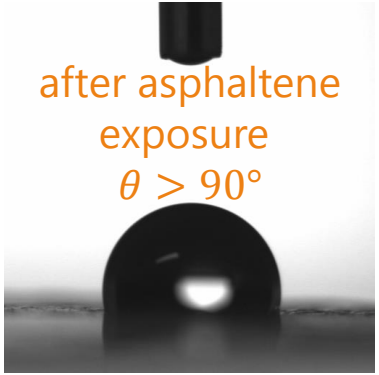


Word cloud of PhD thesis titles 2002 to 2012

Close partnership with industry

- Mapping out parameters that influence oil–water emulsion stability
  - Crude oil composition
  - Viscosity
  - Density
  - Solid particles
  - Adsorption of asphaltenes to solids

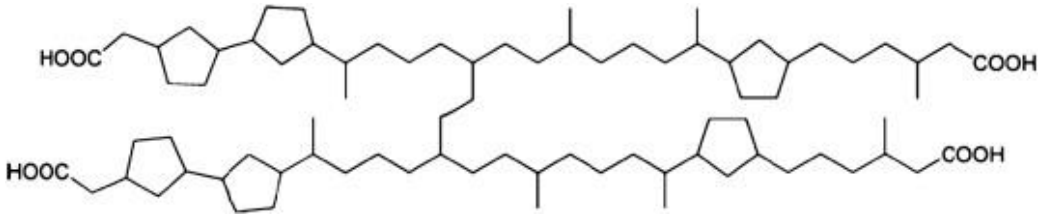




Dudášová, Dorota, et al. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 335 (2009): 62-72.

Close partnership with industry

- Identifying tetrameric acids in deposits
  - Presence problematic for oil production, transport, and separation



Lutnaes, Bjart Frode, et al. *Organic & biomolecular chemistry* 4 (2006): 616-620.
Simon, Sébastien, et al. *Journal of Chromatography A* 1200 (2008): 136-143.

1 Where did we start?

2 Where are we today?

3 What's next?

1 Where did we start?

2 Where are we today?

3 What's next?

Today we are…

Asle Hammer Berget
Jean-Baptiste Boyssou
Bahar Forouzeshrad
Simen Prang Følkner
Zygimantas Gricius
Anil Hatiboglu
Veslemøy Selvik

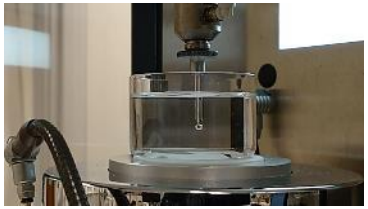
Gisle Øye
Nadia Shardt
Brian Grimes
Kristopher Paso
Kristin Syverud

Nicolas La Forgia
Yujing Liu
Tinku Saikia
Evi Saiti

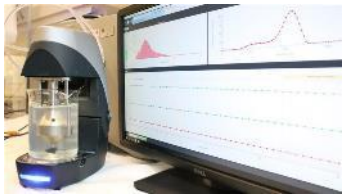
Jens Norrman
Sebastien Simon

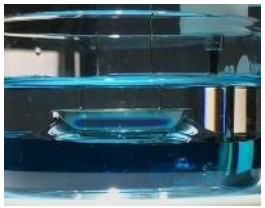
Today we have…

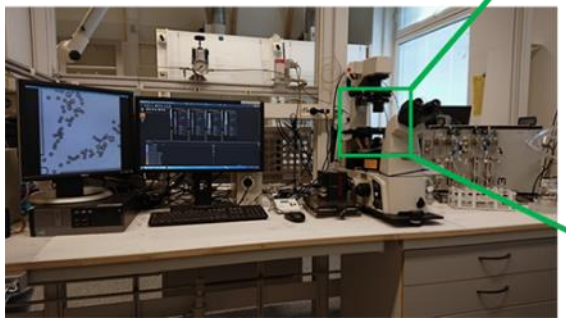
- More updates to experimental facilities

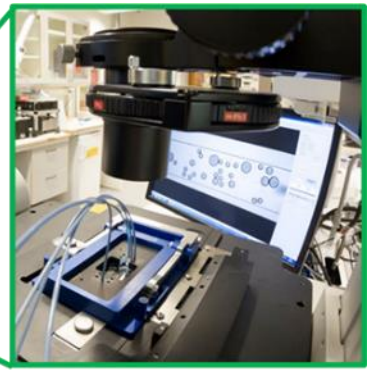


3D printing





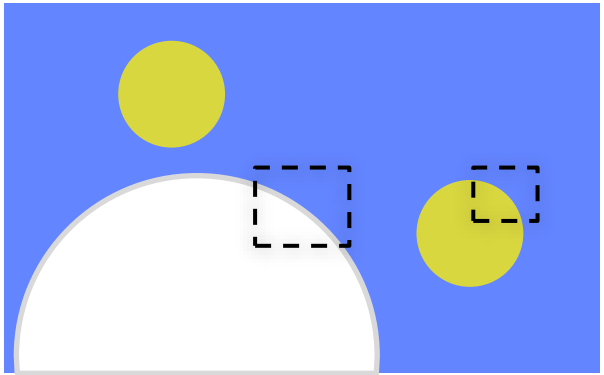




microfluidics

Today we have…

- Investments in computational and software tools



Predict
interfacial properties
equilibrium and dynamic behavior

Interpret
experimental observations (e.g., images)
link between nano- to macroscale

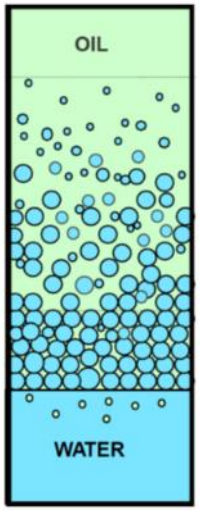
Automate
experimental procedures
data analysis

Computational models

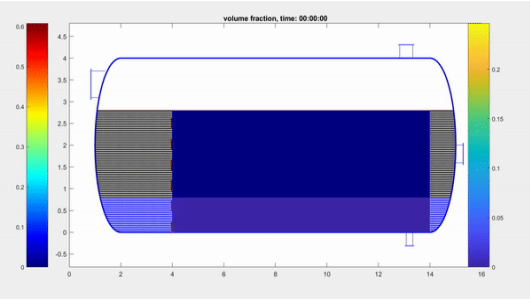
SUBPRO

PBmulib
C++ Numerical Library for
Muli-Phase Fluid PBE Models

- For gravity separation of oil–water emulsions

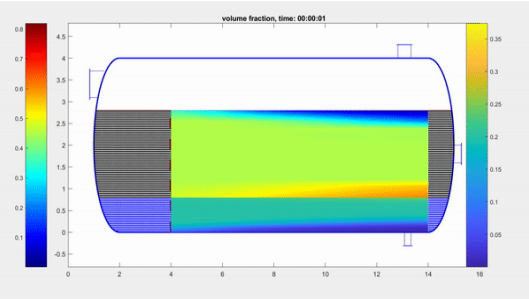


Start-up process



Hydrocarbon and aqueous volume fraction

Shut-down process

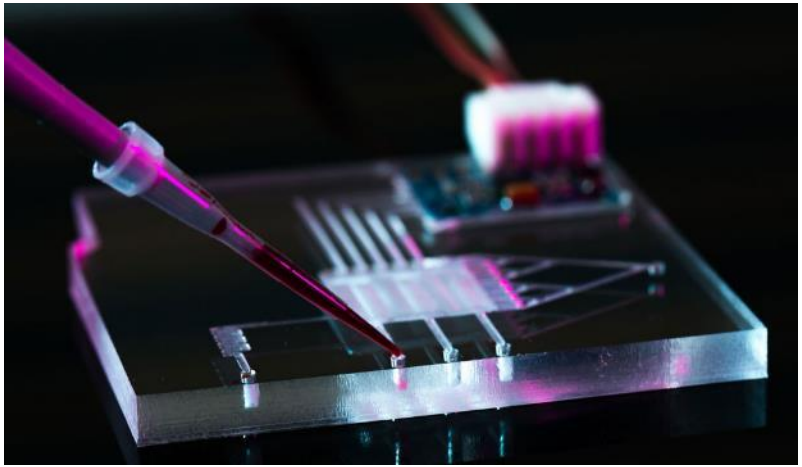


Hydrocarbon and aqueous volume fraction

Assar, Moein, et al. *Chemical Engineering Research and Design* 194 (2023): 136-150.

Experimental microfluidics

- Microfluidics is the control and manipulation of fluids in confined microchannels.



https://www.dantecdynamics.com/applications/microfluidics/

volumes: pL to µL

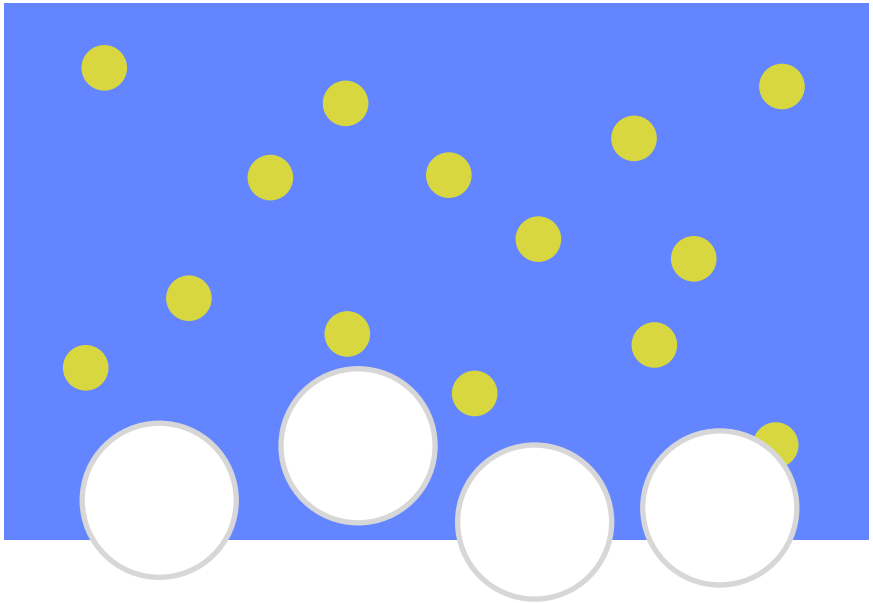
flowrates: nL/min to mL/min

Benefits of microfluidics

- Precise control over experimental conditions
  - Droplet size: monodisperse droplet populations
  - Temperature
  - Concentrations
- Minimal sample and waste volume
- High-throughput or massively parallel experiments
- Ability to monitor temporal changes at the droplet scale
  - Can extract thermodynamic and kinetic properties

Microfluidics for gas flotation

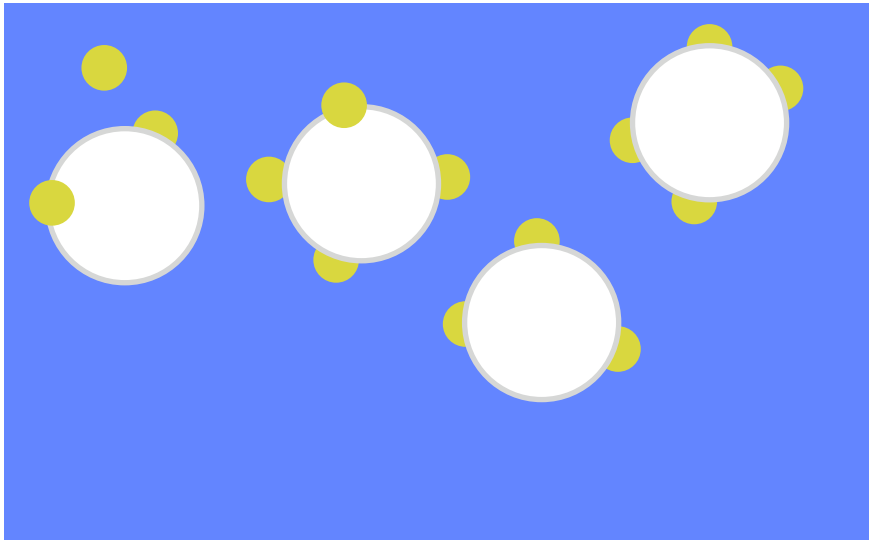
SUBPRO



https://enhydra.co.uk/products/induced-gas-flotation/

Microfluidics for gas flotation

SUBPRO



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Microfluidics for gas flotation

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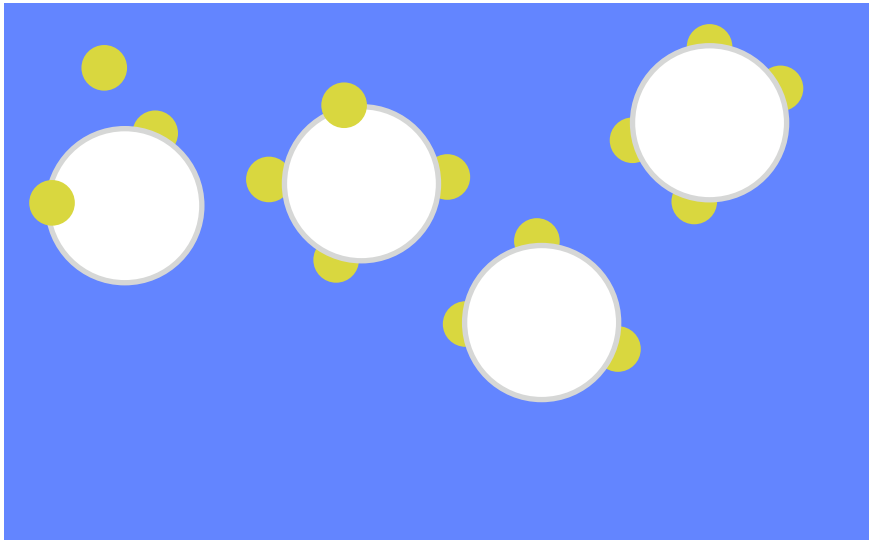


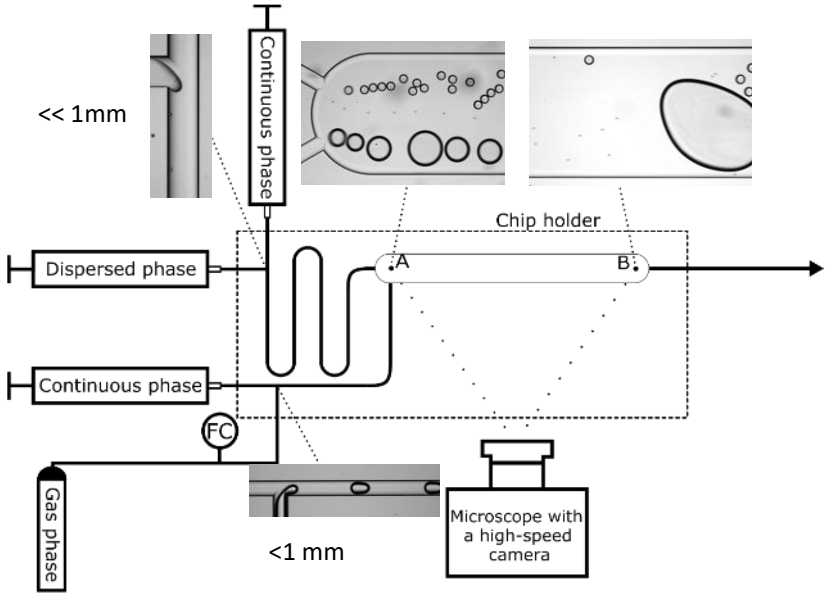
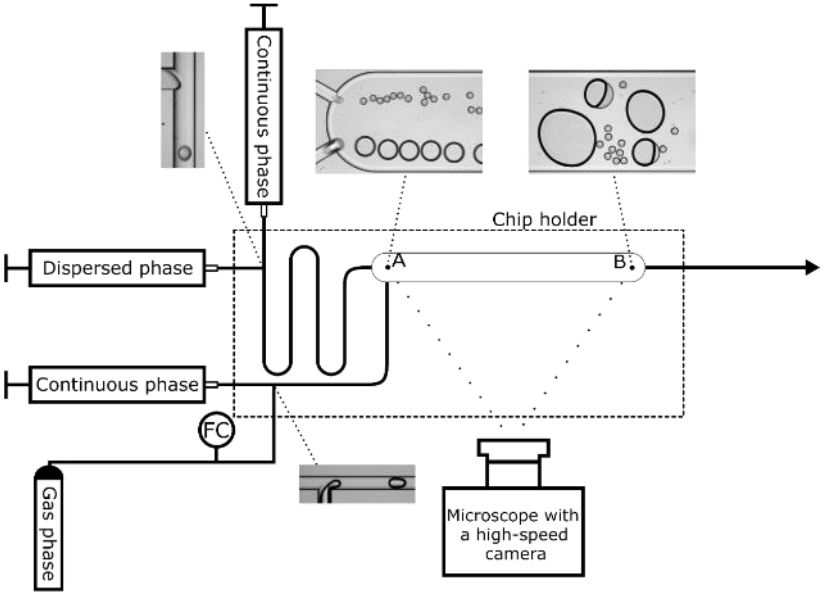
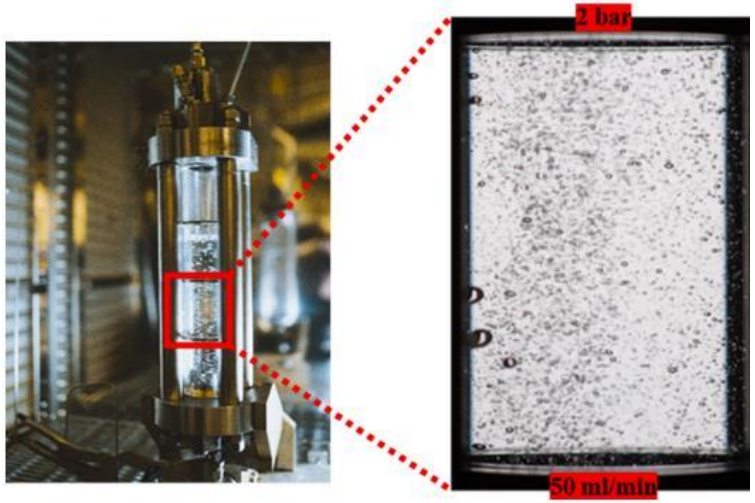


Figure courtesy of Marcin Dudek

Microfluidics for gas flotation

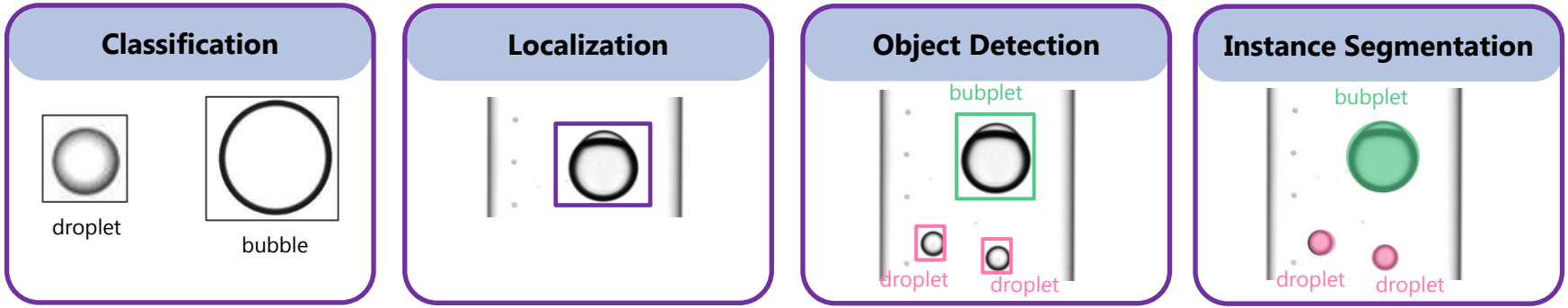
- Linking microfluidic observations to lab-scale flotation rig





Piccioli, Martina, et al. *Energy & Fuels* 37 (2023): 5644-5651.

Computer vision for microfluidics



Assigns label to the entire image

Locates the main object of the image

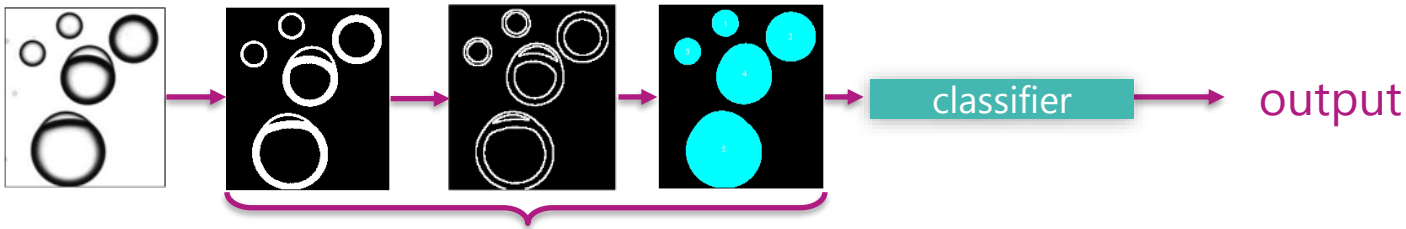
Identifies objects and their positions with bounding boxes

Detects multiple objects and their actual shape

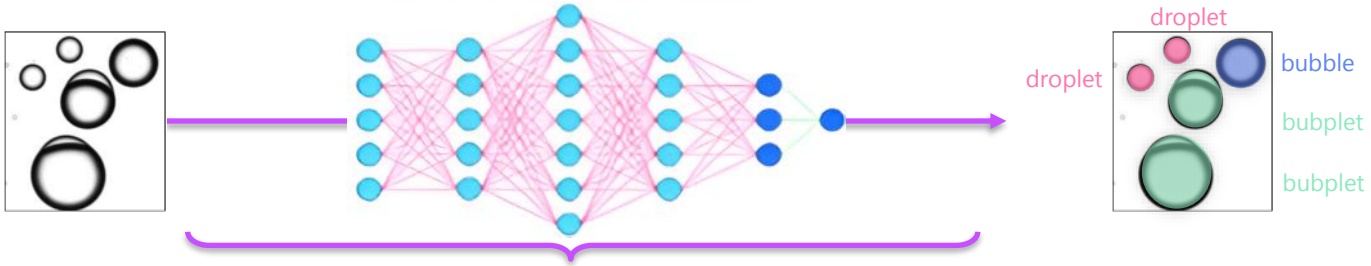
Figure courtesy of Evi Saiti

Computer vision for microfluidics

Conventional



Deep Learning

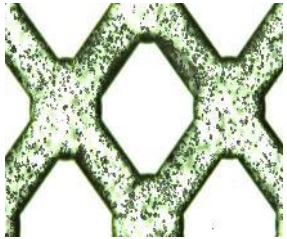


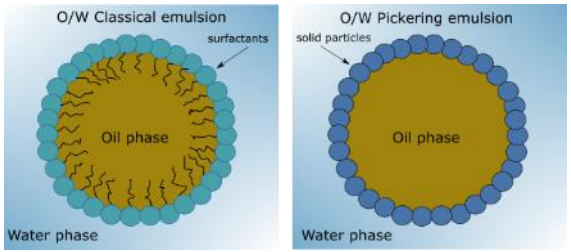
feature learning + classifier = end-to-end learning

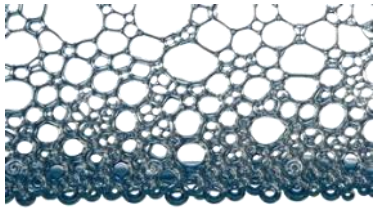
Figure courtesy of Evi Saiti

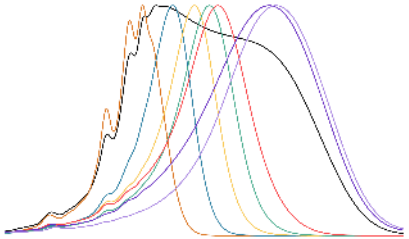
And more…

- Flow through porous media glass micromodels
- Synthesis of nanoparticles for water treatment
- Microfluidic studies of foam stability
- Lignosulfonate fractions as dispersants for industry
- Nanoparticles for CRISPR delivery





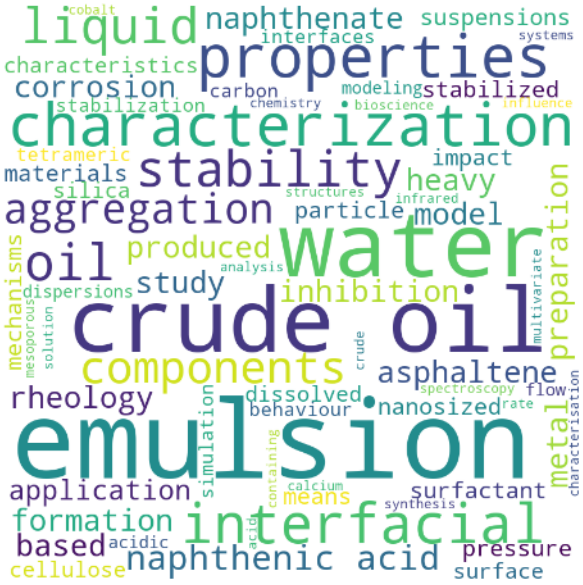




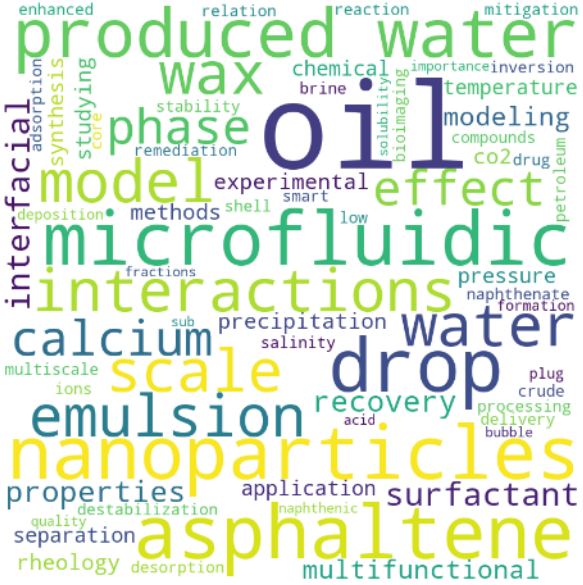
Today we have…

- Students trained in colloid and polymer chemistry

2002 to 2012



2012 to present day



1 Where did we start?

2 Where are we today?

3 What's next?

1 Where did we start?

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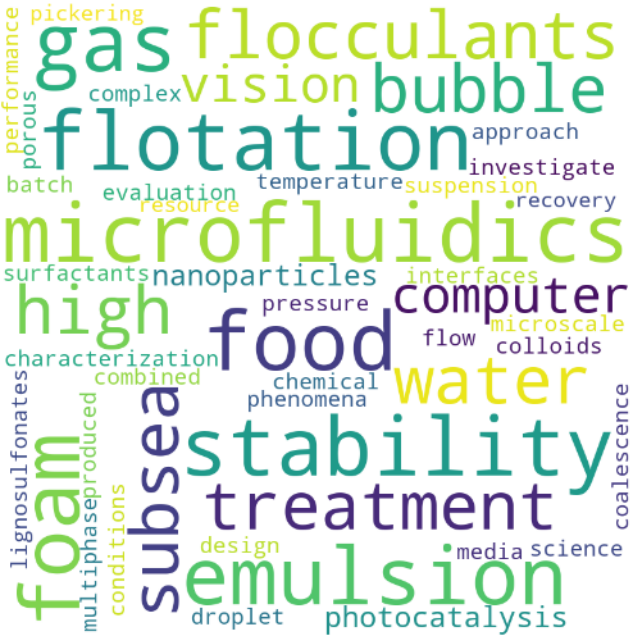
What’s next?

Colloids and polymers applied to
- Water treatment and management
- Resource recovery
- Reservoir injection
- Food processing

Tool development
- Rational design and screening
- Microfluidic techniques
- Computer vision
- Computational models



What’s next?

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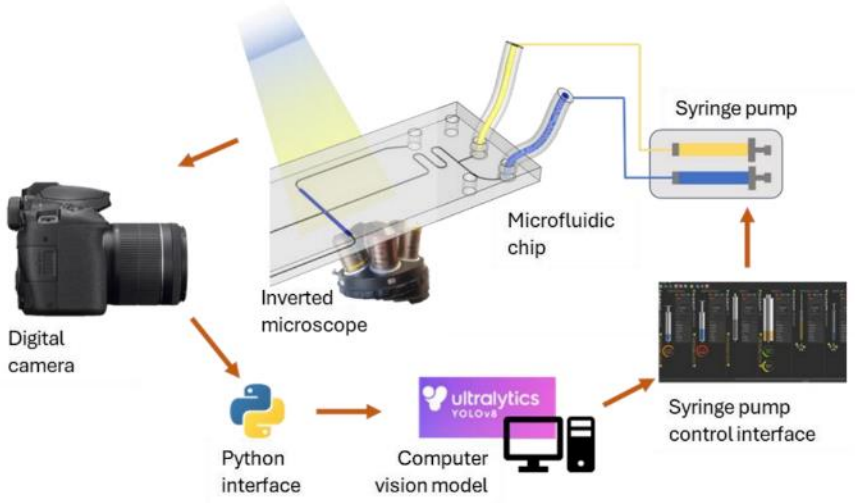

Figure courtesy of Anil Hatiboglu

What's next?

nano scale	micro scale	macro scale	industrial scale
molecular dynamics	interfacial properties	dispersion stability	water treatment
surface interactions	crystallization	material properties	gas flotation
nanoparticle synthesis	adsorption & desorption	flow in porous media	CO_2 capture
thermodynamics	agglomeration	new material synthesis	food processing

towards sustainable development

NTNU