



Subsea separation: Fluid Characterization

Gisle Øye



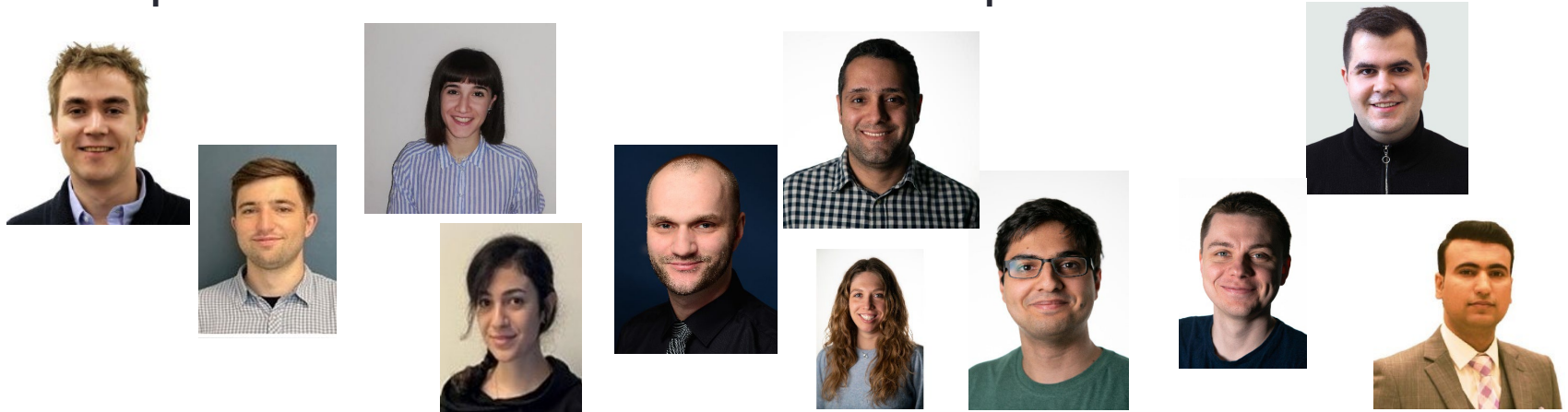
Overview of projects

- Produced water quality, Marcin Dudek, PhD – completed 2018
- Wax crystallisation, Jost Ruwoldt, PhD – completed 2018
- Sequential separation, Are Bertheussen, PhD – completed 2018
- Modelling of coalescence, Aleksandar Yordanov, post.doc – completed 2018
- Influence of chemicals on produced water quality, Marcin Dudek, post.doc – completed 2022
- Dispersions in porous media – re-injection of produced water, Ilgar Azizov, PhD – completed 2022
- Gas flotation for subsea produced water treatment, Martina Piccioli, PhD – ongoing (completed 2023)
- Flow improvers for waxy crudes, George Claudiu Savulescu, PhD – ongoing (completing 2024)
- Multiphase separation and transport model library, Moein Assar, PhD- ongoing (completing 2023)
- Re-injection of produced water – co-flow of particles and droplets visualized using microfluidic and advanced image analysis methods, Husnain Ahmed, Researcher (completed 2023)

People



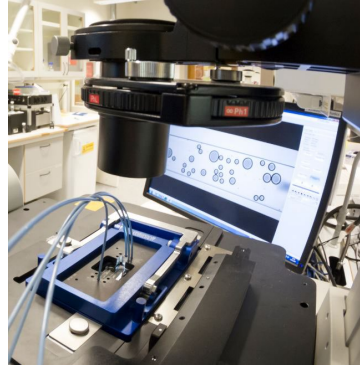
PhDs/post.docs/researchers/master students/internships



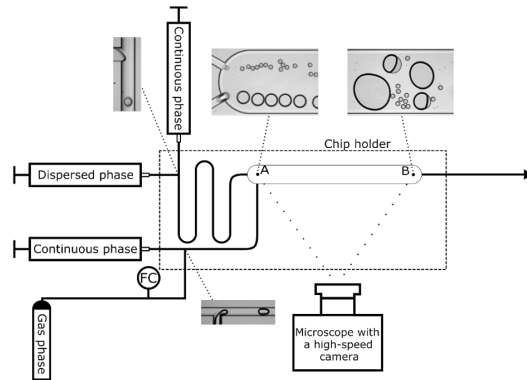
Supervisors



2015



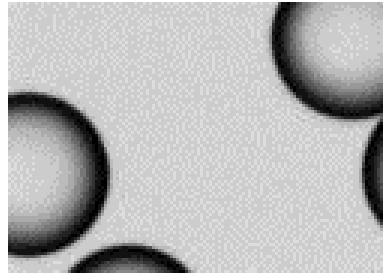
2023



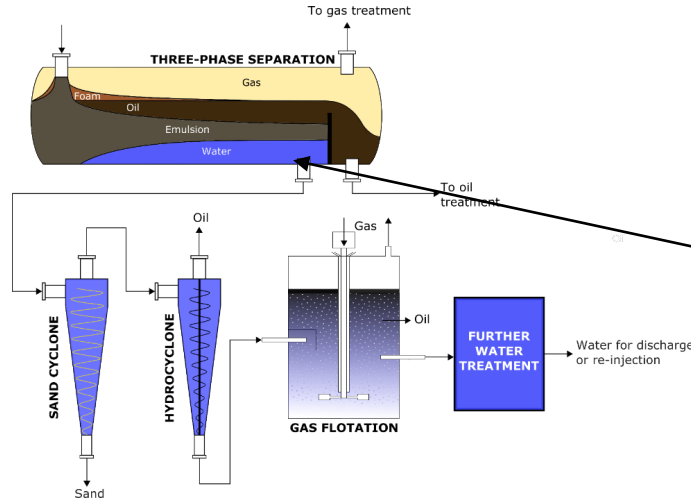


Why Fluid Characterisation?

The efficiency of macroscopic processes, like separation and transport of fluids, is tightly linked to microscopic and interfacial phenomena



Produced water - interfaces



- Dispersed solids
- Dispersed oil (o/w emulsions)
- Dissolved gas and organics

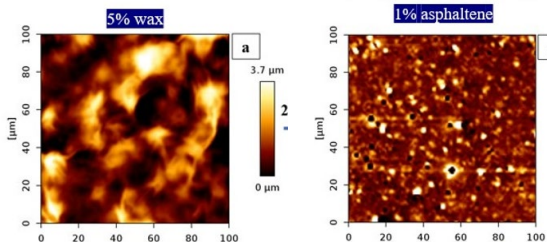
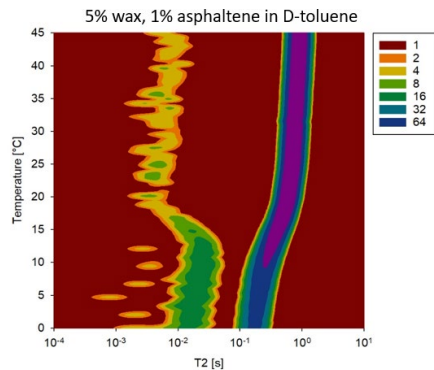
Bubbles in flotation unit: 15 000 m³ PW/day, 10% gas, d=200 μm

Interfacial area: 45×10⁶m²/day



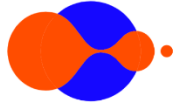
- Flow assurance – wax precipitation
- Separation – produced water management

Wax crystallisation



	1a 5% wax in toluene	1b 5% wax, 0.5% asphaltene in toluene	1c 5% wax, 1% asphaltene in toluene	1d 5% wax, 1% PPD in toluene
Crystal network-Model (4 crystals)				
Crystal pores	2a Wax crystal Larger crystal size, wide pores	2b Intermediate wax crystal Larger crystal size, wide pores	2c Wax-asphaltene co-crystal Smaller crystal size, narrow pores	2d Wax-PPD co-crystal Small size, very wide pores
Formation of a softer layer interacting with dissolved wax	3a	3b	3c	3d
Dissolved wax	Low amount of dissolved wax trapped		High amount of dissolved wax trapped	Large wax-PPD complexes, no trapping
Toluene	Low mobility for toluene		High mobility for toluene	Very high mobility for toluene
Asphaltene	nanoaggregate/cluster	PPD	Co-crystallization High interactions nanoclusters-trapped wax	Co-crystallization Large wax-PPD complexes, high solubility

A Digital Library for Oil/Water Emulsion Separation and Transport Processes



PBmulib

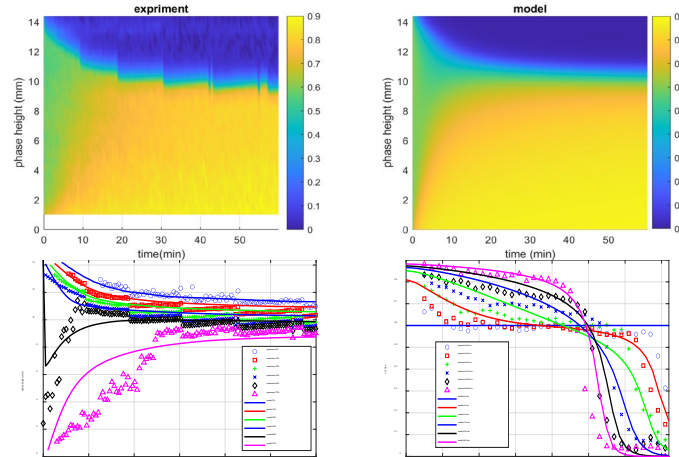
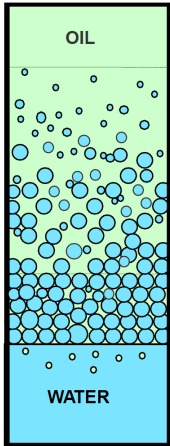
C++ Numerical Library for
Multi-Phase Fluid PBE Models

Main Achievements:

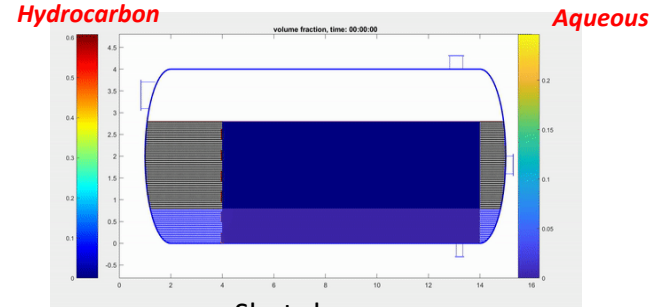
- A C++ model library for fast and robust computation of PBM with various complexities
- Modular simulations for transport and separation of oil and water emulsions
- A new model for formation of dense packed layer in gravitational separation process
- The model was tuned and validated using data from TotalEnergies project performed in Ugelstad Lab
- Extending the model to 3-phase separator

Stabilized water in model oil emulsion

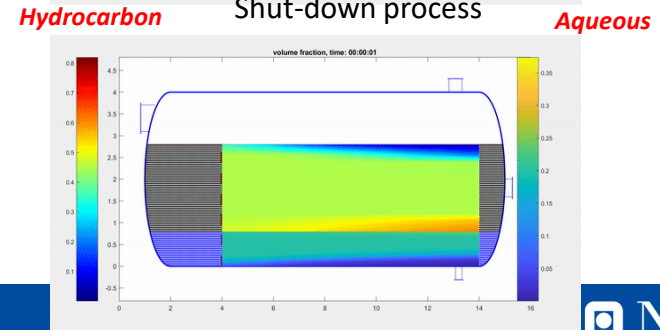
Volume Fraction = 60%



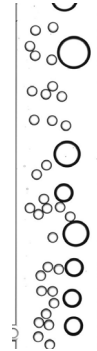
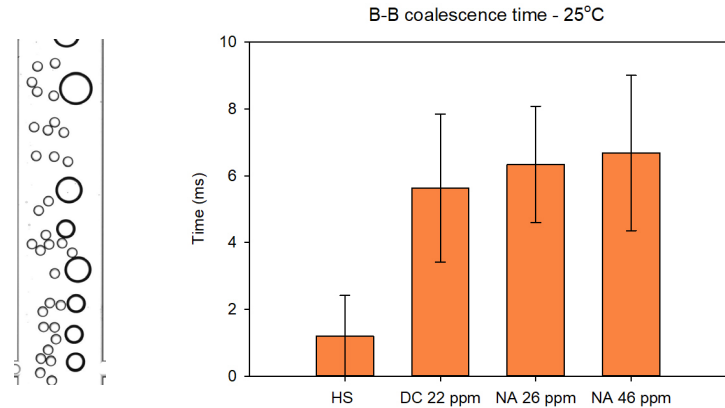
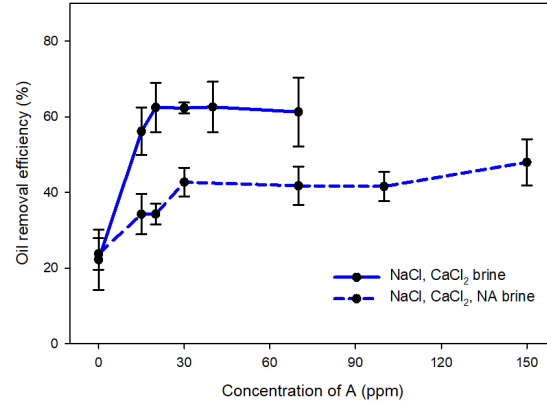
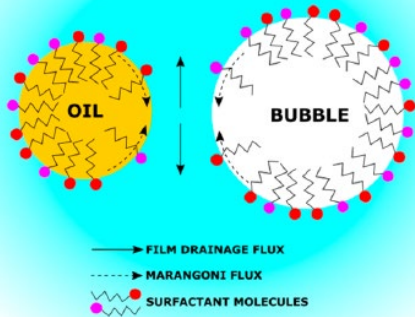
Start-up process



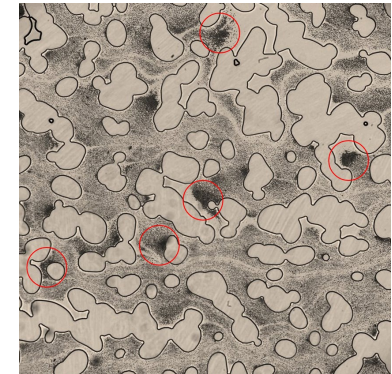
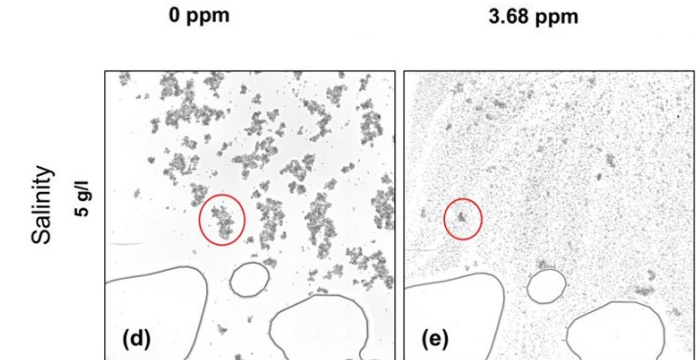
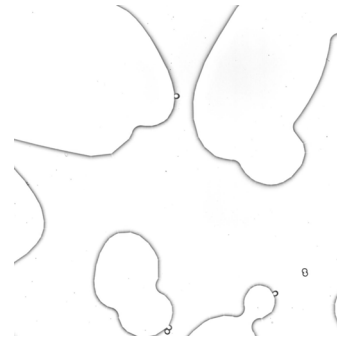
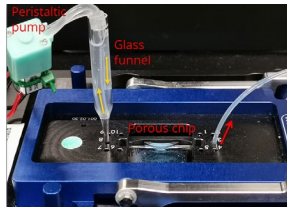
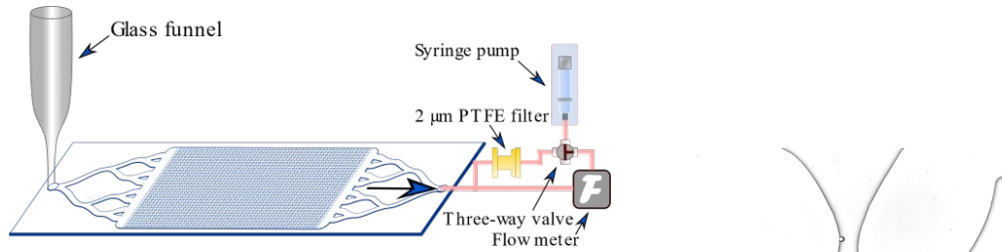
Shut-down process



Gas flotation



Produced water re-injection



Acknowledgements



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