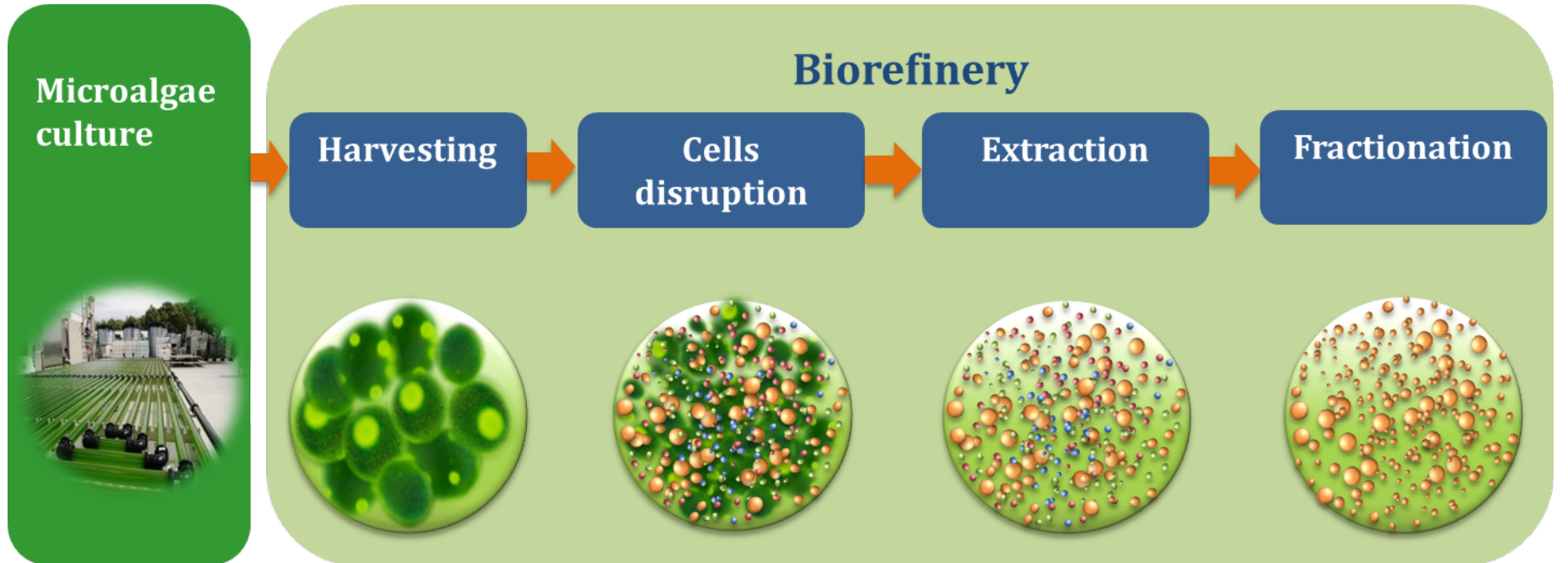


Understanding microalgae lipids recovery by membrane processes: cross-flow filtration of a representative synthetic mixture

Erika Clavijo

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P. Bourseau, M. Frappart, C. Monteux, E. Couallier

1. Context: Microalgae biorefinery

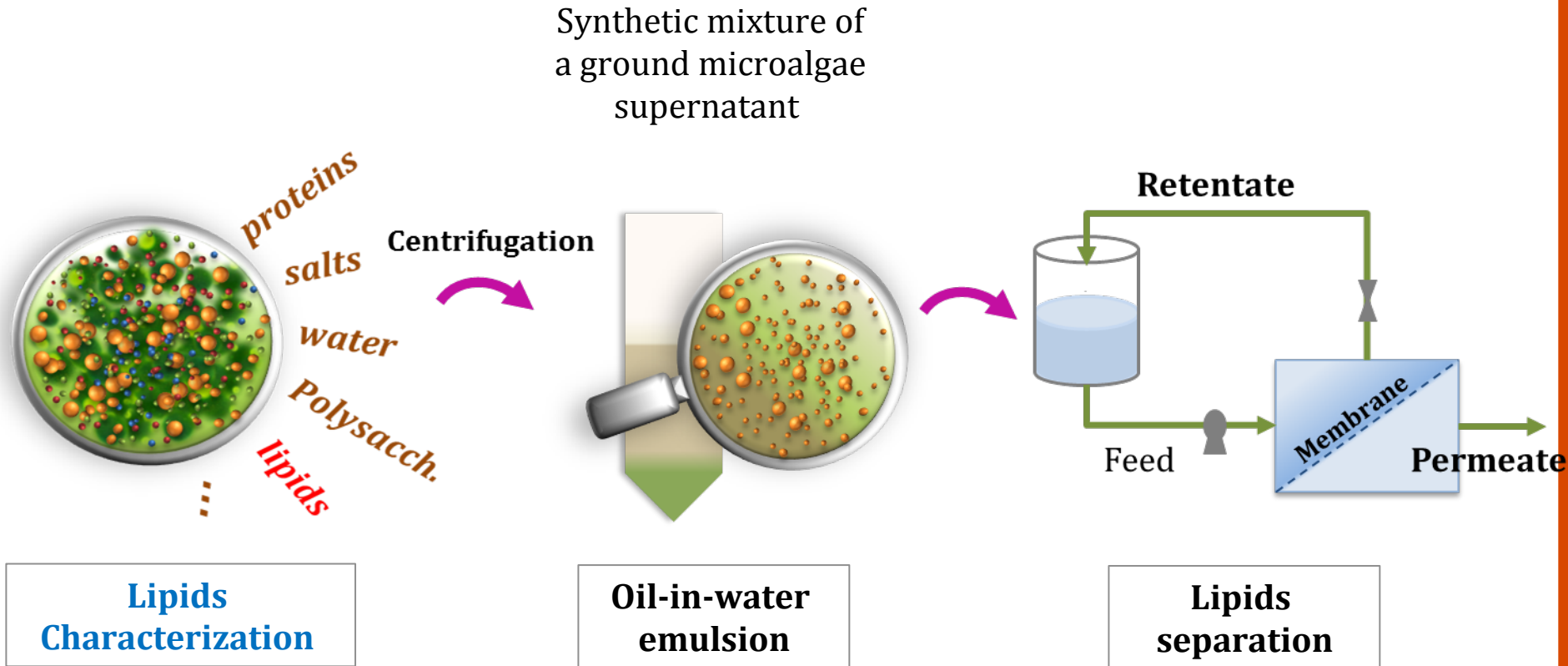


Parachlorella kessleri can accumulate up to **45% (w) of lipids** of the dry matter (Montalescot, 2015)

Complex mixture of suspended cellular components

Interfacial phenomena impact the **membrane filtration process**: lipid droplets stabilized by the polar compounds deeply impact the triglycerides (TAG) recovery.

2. Objective



Objective: understanding lipids separation by membrane processes from a synthetic mixture of ground microalgae, in presence of polar compounds stabilizing the water-oil interface

3. Methodology: 3 stages

1

Stage I:
Definition of a microalgae synthetic mixture (o-w emulsion)



P. kessleri ground microalgae samples characterization

Particle size analysis

Lipids profile

2

Stage II:
Interfacial phenomena at the emulsion L-L interface

Surfactants at the oil-water interface

Interfacial tension: pendant drop method

Surfactants at the air-water interface

-Pressure – area isotherms (Langmuir balance)
-Monolayer observation (AFM)

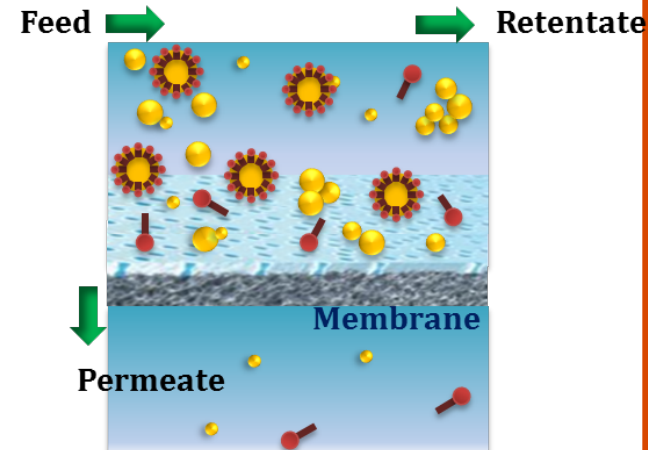
3

Stage III:
Lipids separation by Membrane filtration



Test of 5 membranes:

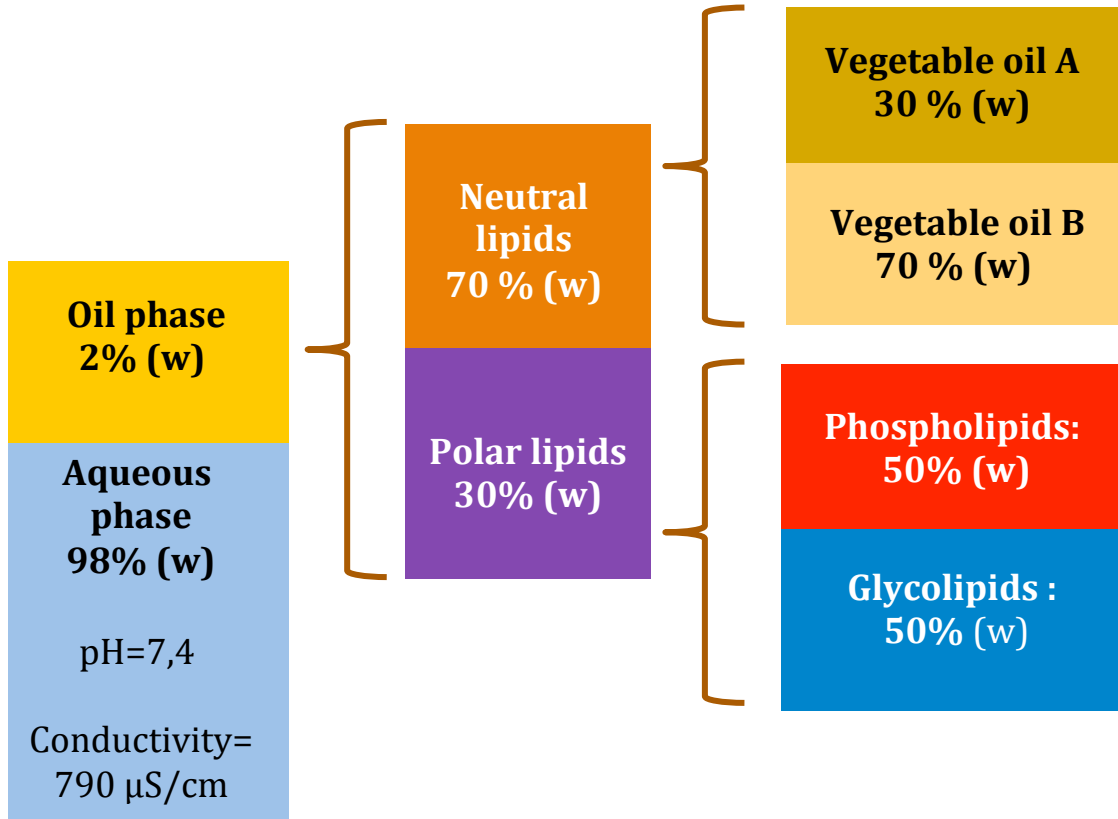
- PES 200kDa et 300kDa
- PAN 500kDa
- PVDF 0.4 et 1.5 μm



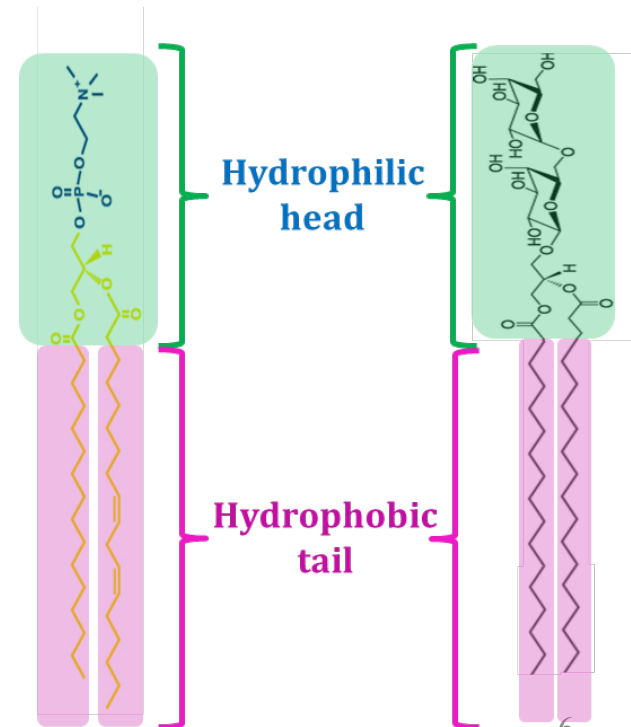
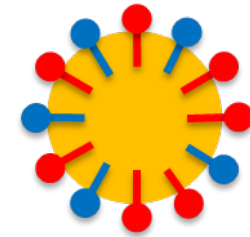
1

Stage I:
Definition of a microalgae synthetic mixture
(o-w emulsion)

4. Results - Stage I: Synthetic mixture formulation



Surfactants at the oil-water interface

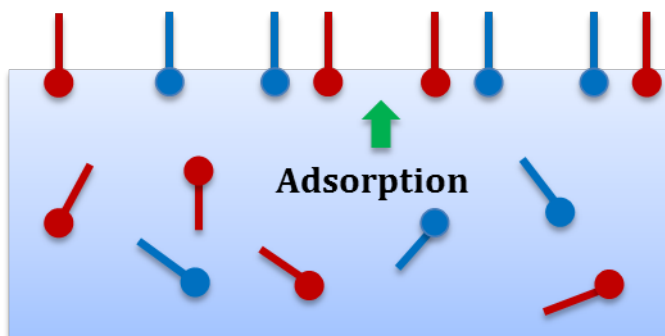


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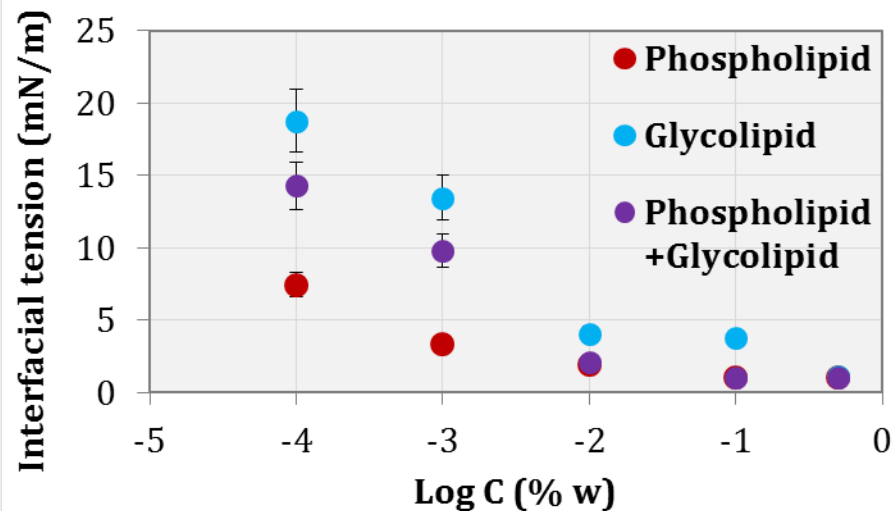
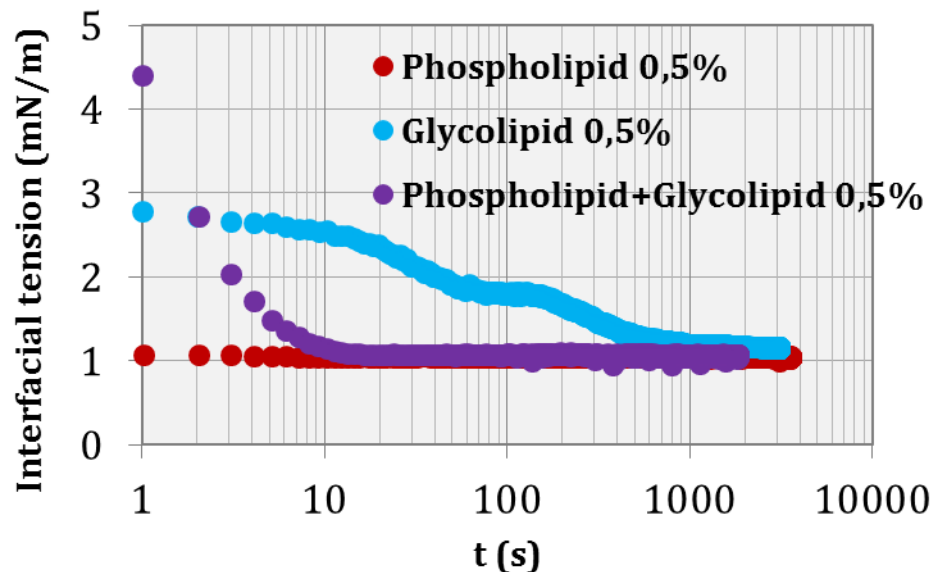
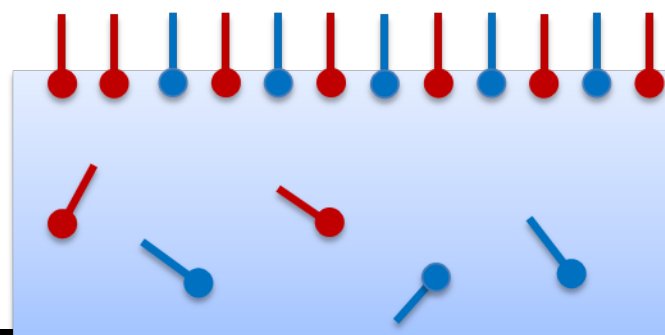
Stage II: Interfacial phenomena at the L-L interface

5. Results - Stage II: oil-water interface characterization

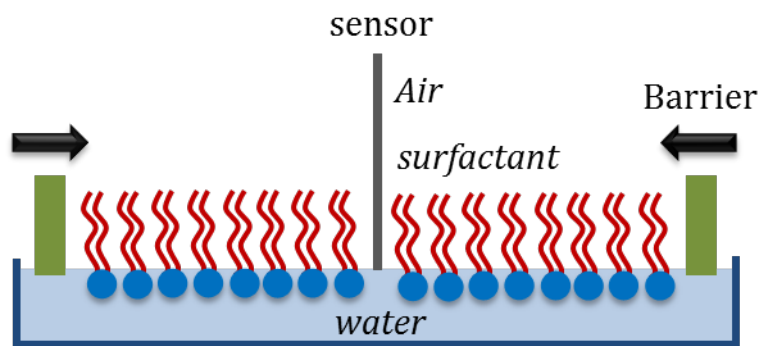
Adsorption at the interface



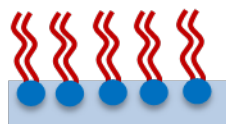
Interface at the equilibrium



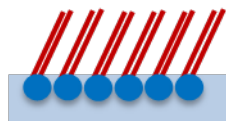
5. Results - Stage II: air-water interface characterization



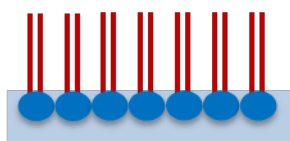
Gas
(G)



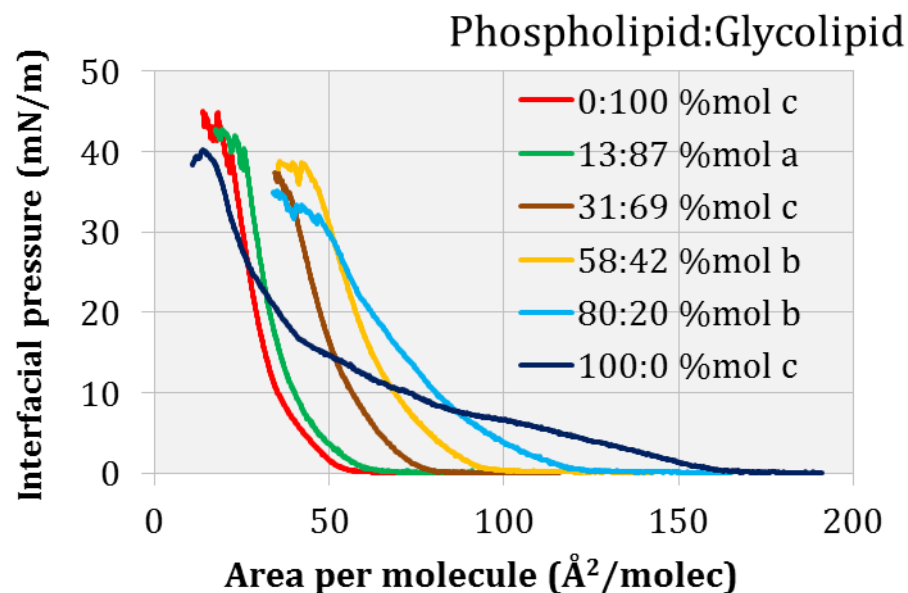
Expanded
Liquid (EL)



Condensed
Liquid (CL)



Solid
(S)

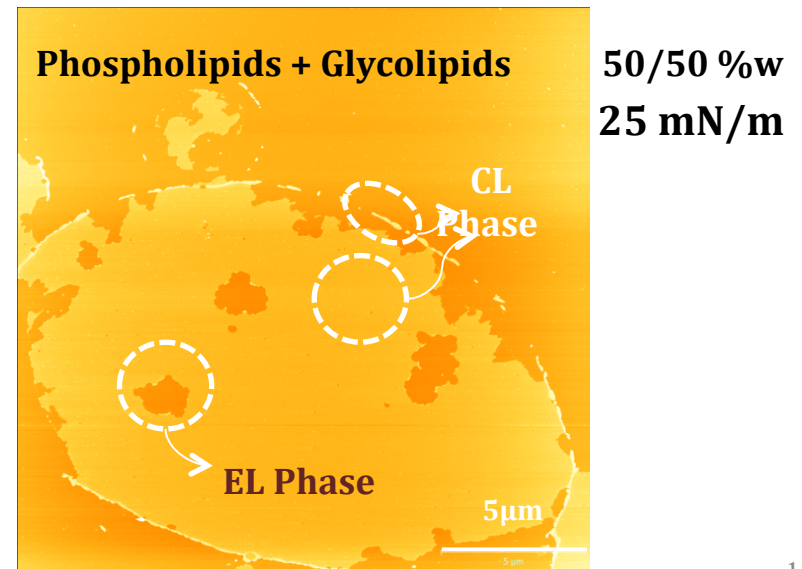
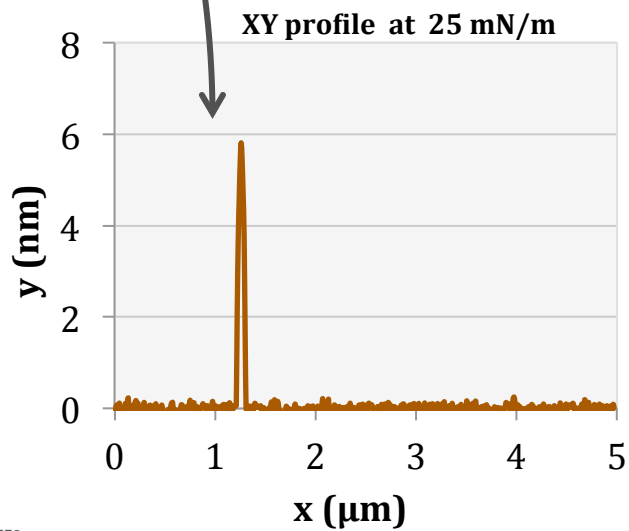
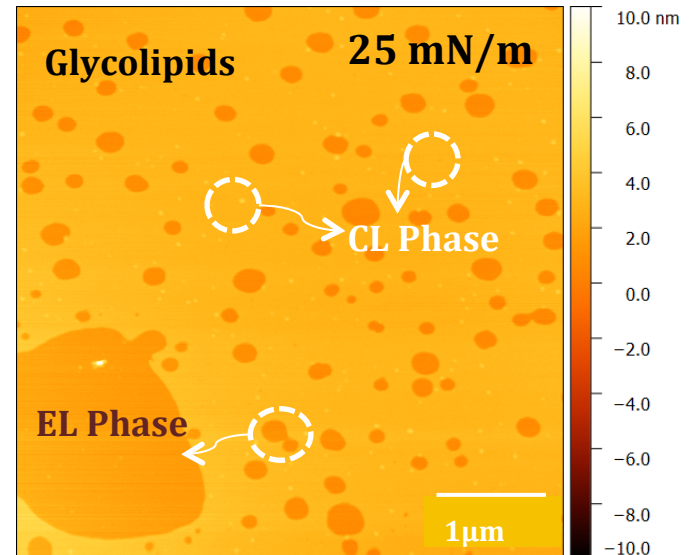
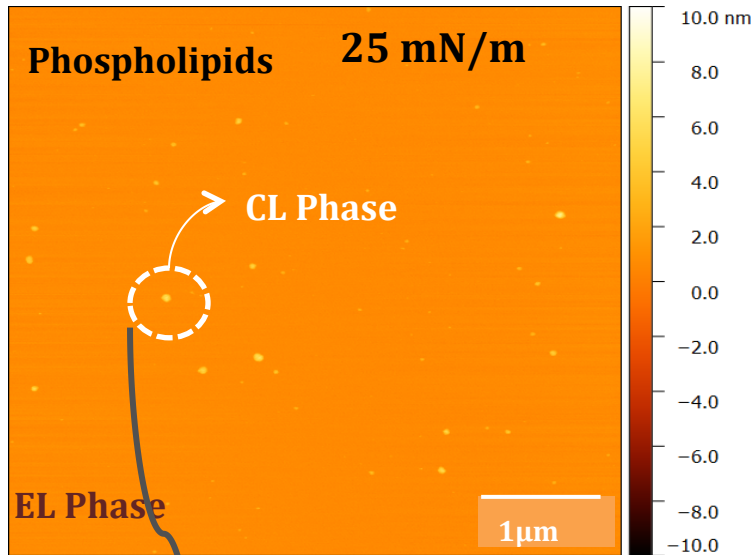


$$\Pi = \gamma \downarrow 0 - \gamma$$

Glycolipid gives **stability** to the monolayers
 → more of **CL** phase

Phospholipid form more **fluid monolayers**
(EL) and gives more flexibility to the interface

5. Results - Stage II: monolayer AFM analysis

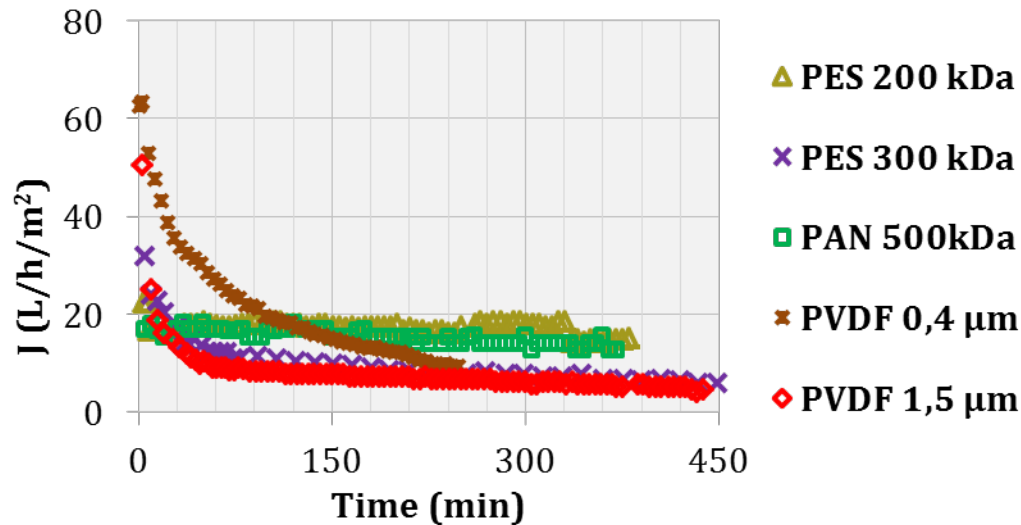


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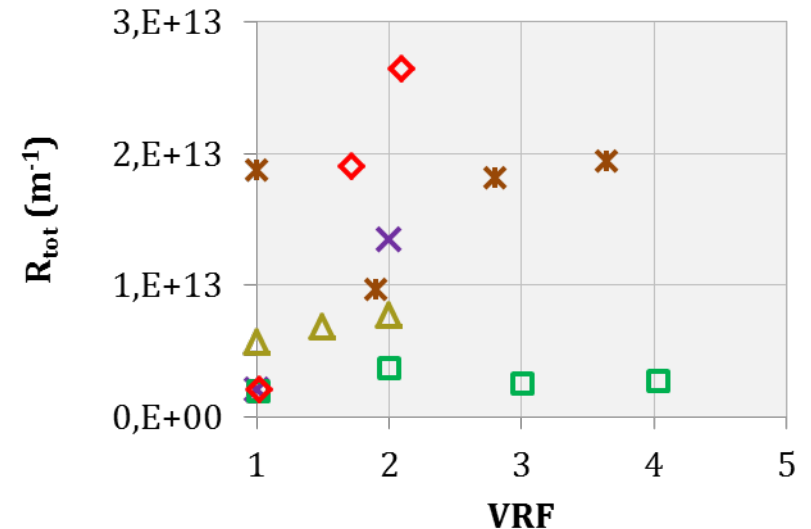
Stage III: Lipids separation by membrane filtration

6. Results - Stage III: lipids separation by membrane filtration

Permeate flux evolution during the emulsion filtration



Total Resistance evolution during the emulsion filtration



$P_w = 0,2$ to $0,3$ bar
 $T = 30^\circ\text{C}$
 $v = 1\text{m/s}$

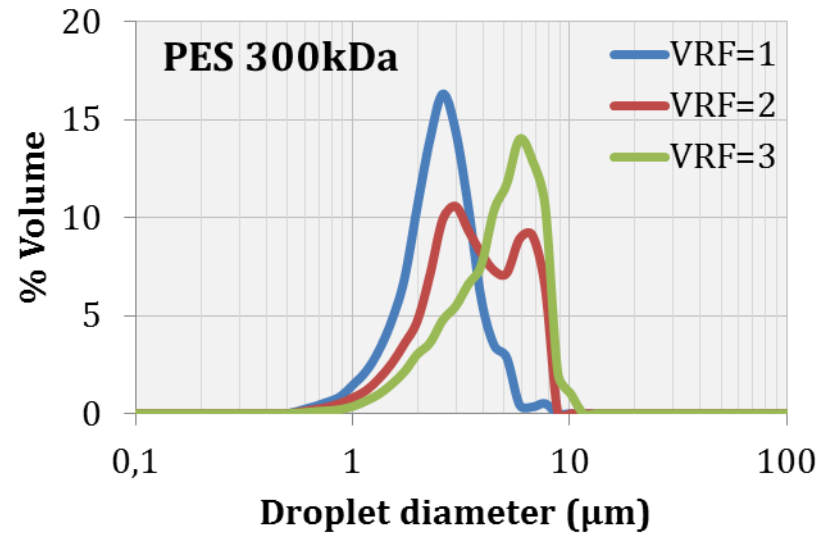
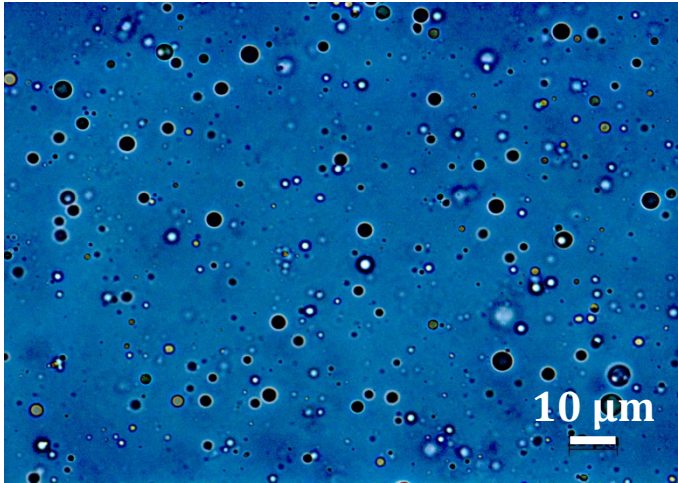
+ hydrophilicity



PAN / PES 200 / PVDF 1.5 / PES 300 / PVDF 0.4

6. Results - Stage III: lipids separation by membrane filtration

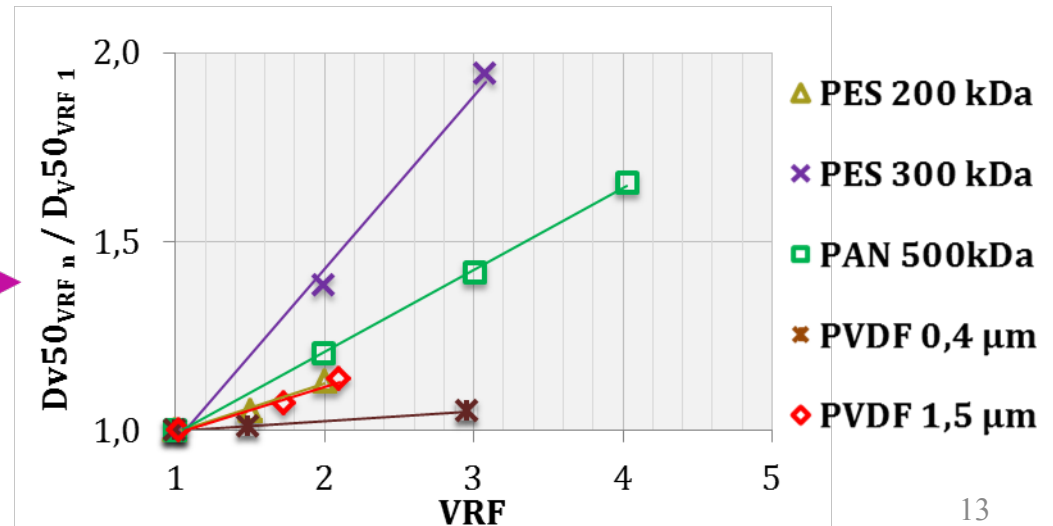
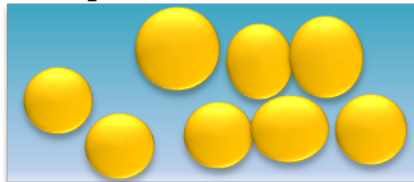
Emulsion granulometry evolution during filtration



Droplets size reduction?



Droplets coalescence?



7. Conclusions

Stage I:

- *P. kessleri* ground samples were **characterized** and a **synthetic mixture** was obtained as an oil-in-water emulsion. The lipid phase was composed by a mixture of Vegetable oil, phospholipids and glycolipids.

Stage II:

- **Surfactant mixture** behavior is close to the **phospholipid**.
- **Non-synergistic** behavior was observed between surfactants.
- **Phospholipid** was more efficient for the **reduction of the interfacial tension** than glycolipid.

Stage III:

- The **PAN 500kDa membrane** exhibited the most **suitable characteristics** for oil concentration purposes in terms of permeate flux, retention and cleanability.
- **Coalescence phenomena** was observed during filtration suggesting that shearing forces may destabilize the interface → rearrangements at the interface may leads to destabilization

Atlantic ocean

La Baule

Saint-Nazaire

GEPEA lab. (CRTT)

AlgoSolis R&D facility

Polytech'Nantes
Graduate school of the University of Nantes
Process and Bioprocess Engineering



UNIVERSITÉ DE NANTES



ALGOSOLIS
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Thank you for
your attention