# Fatty acid assemblies: from bulk to interfaces


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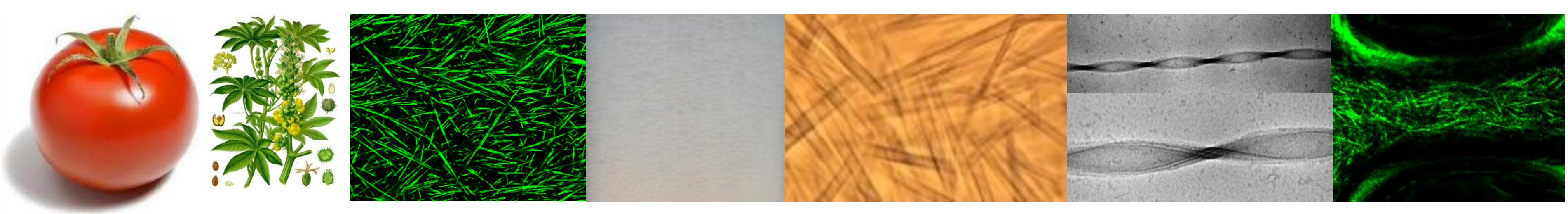
*[2]Biopolymères Interactions et Assemblages, INRA Nantes, 44316 Nantes, France*

# Context

Surfactants

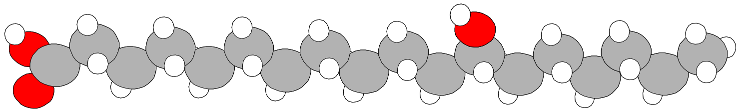
# Context

Green chemistry

# Context

Green chemistry

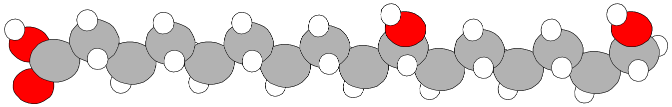
Hydroxylated fatty acids



Castor oil plant

Green surfactants

# Scientific challenges

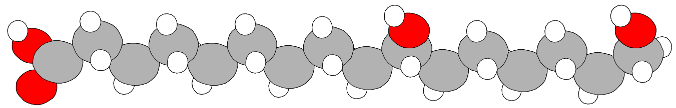


FA chain long → insolubles in water

↓

How to disperse them?

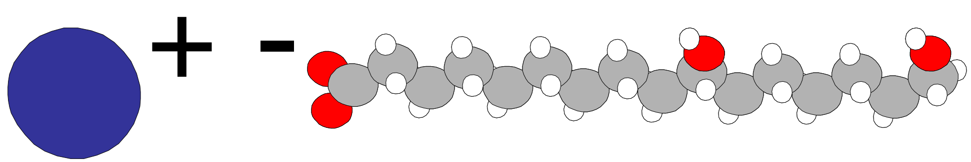
# Scientific challenges



FA chain long → insolubles in water

How to disperse them?

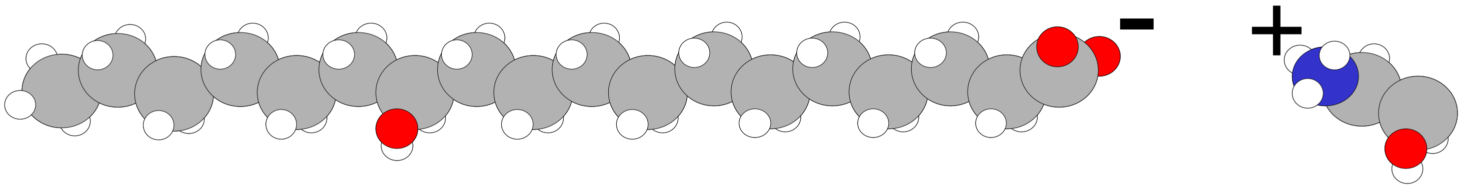
Strategy




Fatty acids salt

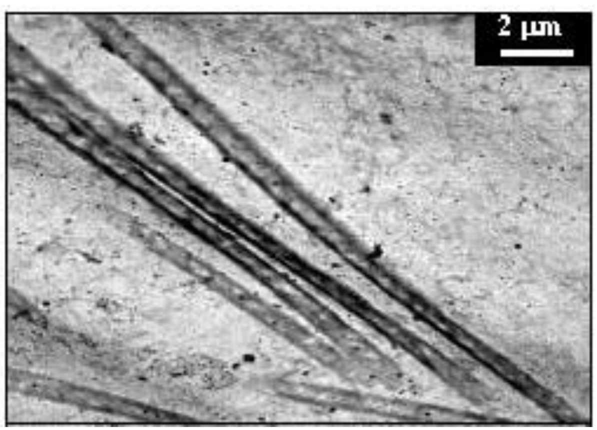

Klein R., Touraud D., & Kunz W., (2008) Green Chemistry 10, 433-435.
Zana R. (2004) Langmuir, 20, 5666-5668.

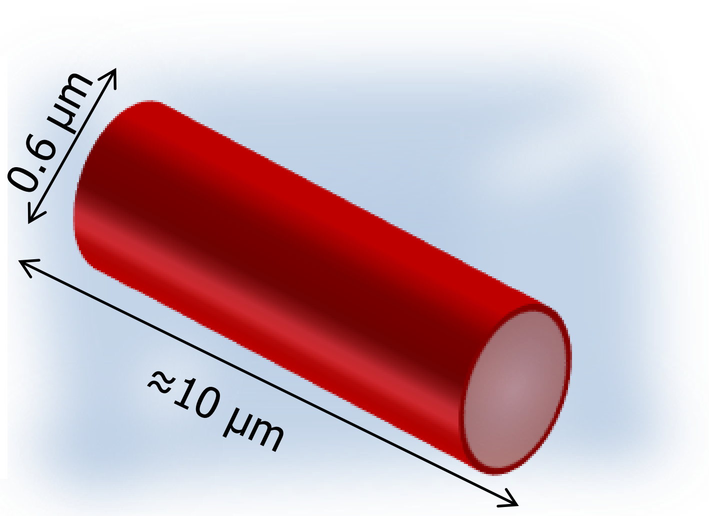
# A System with a hierarchical structure




12 hydroxy-stearic acid

2 amino 1 ethanol




Douliez J.P., Gaillard C., Navailles L., & Nallet F., (2006) Langmuir, 22, 2942-2945.

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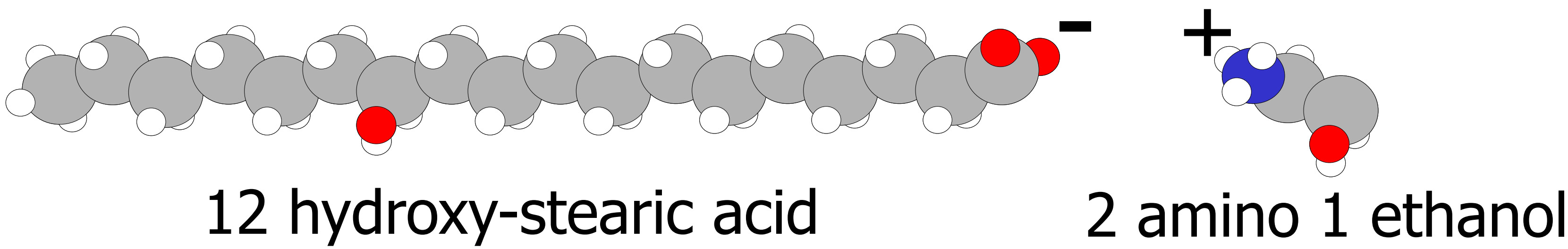


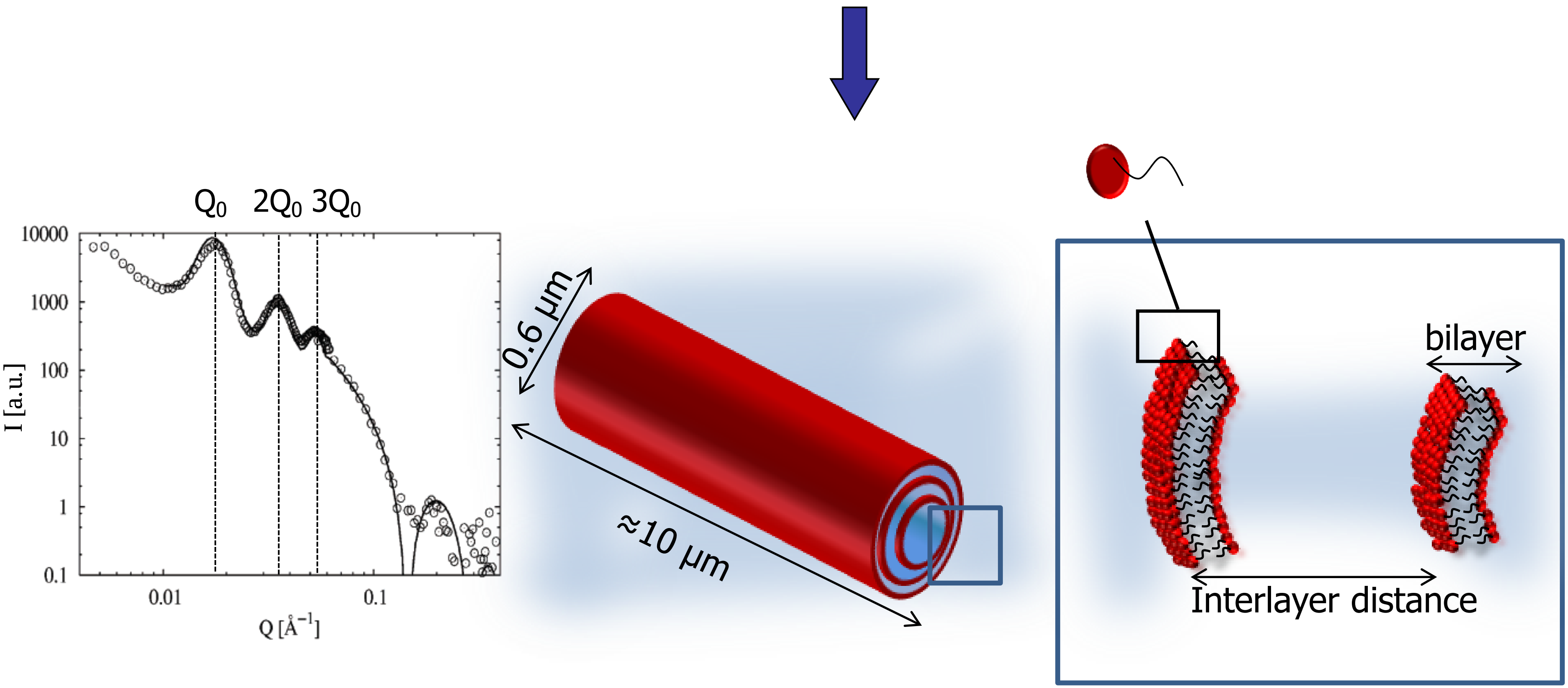


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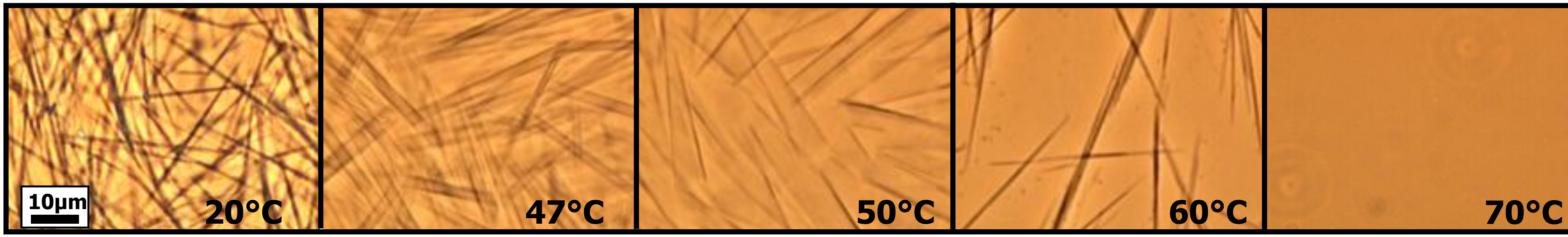
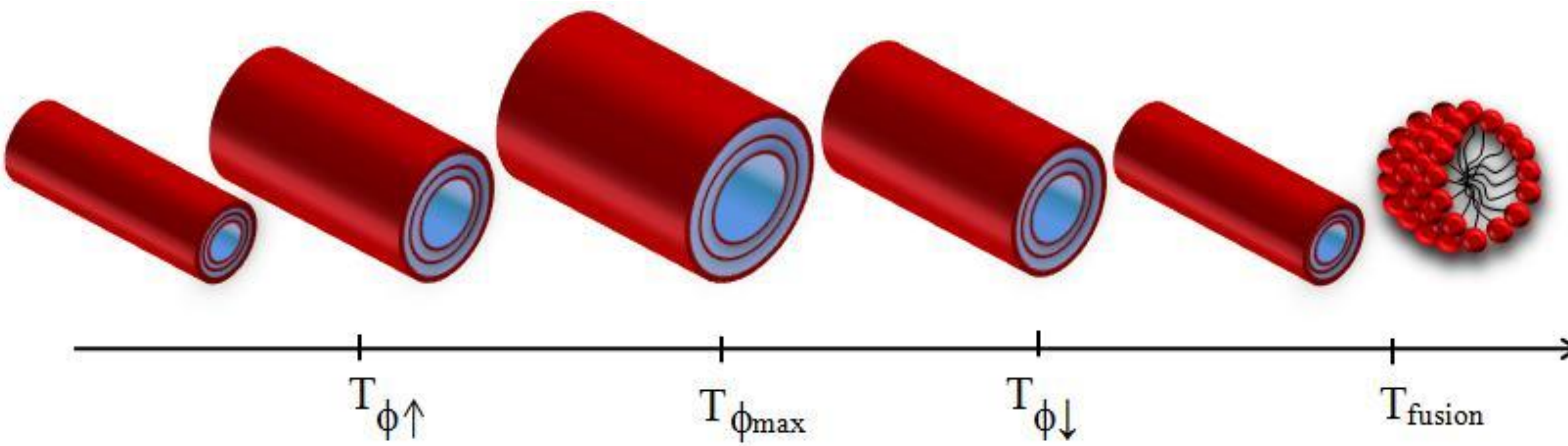
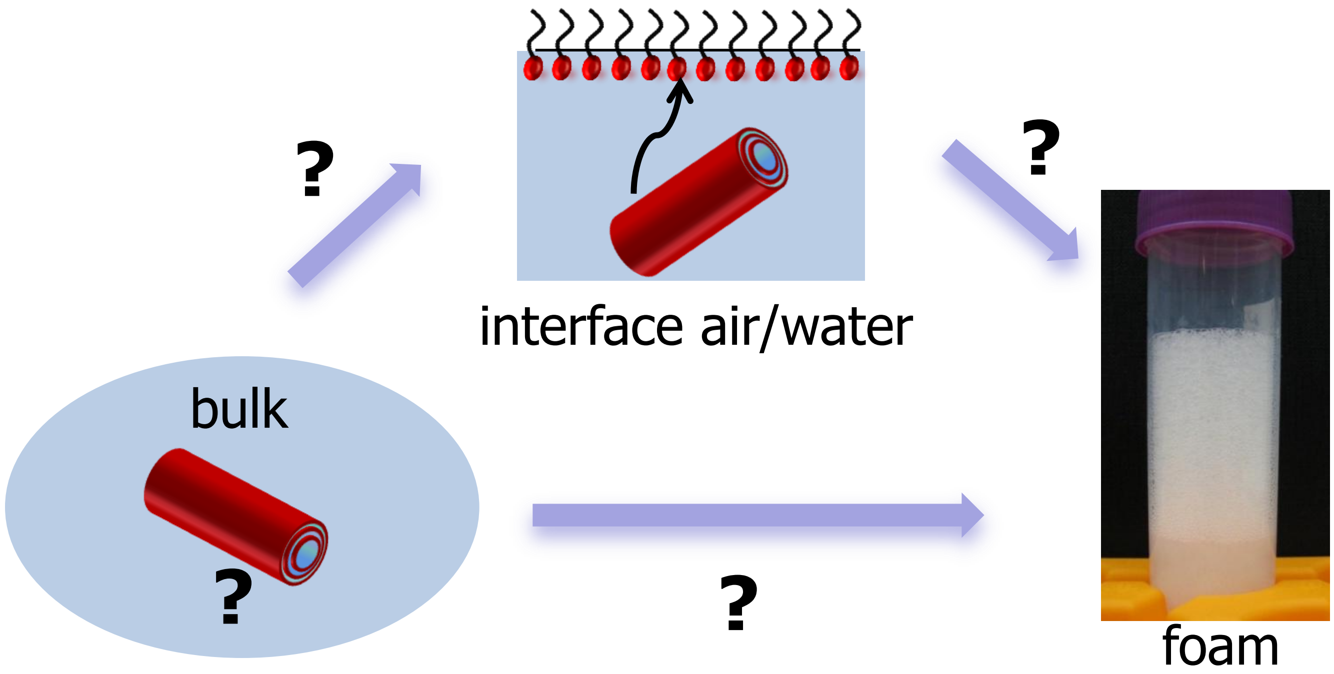
# Tubes diameter is tuned by the temperature



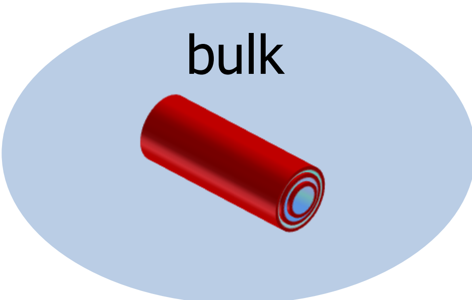

Douliez J.P., Pontoire B., & Gaillard C., (2006) ChemPhysChem, 7, 2071-2073.
Fameau A-L., *et al*. (2010) Journal of Colloid and Interface Science, 341, 38-47.
Fameau A-L., *et al*. (2011) Journal of Physical Chemistry B, 29, 9033-9039.

# Thesis project

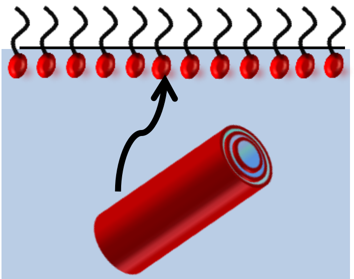



- Specific properties of tubes in bulk?
- Confinement of tubes at interface?
- Structure of tubes into the foam ?
- Is it possible to obtain thermo-responsive foams?

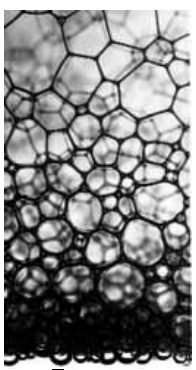
# Outline




Presentation of the system in bulk

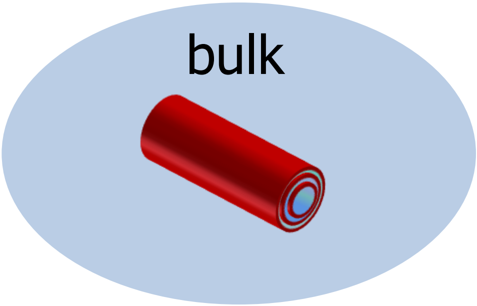



Structure of tubes at the air/water interface?

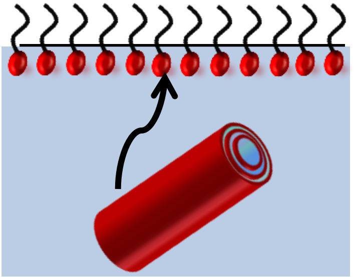



Foaming properties of tubes

# Outline

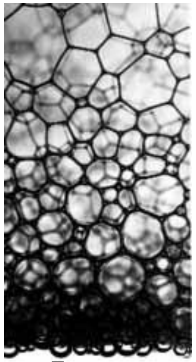



Presentation of the system in bulk



interface

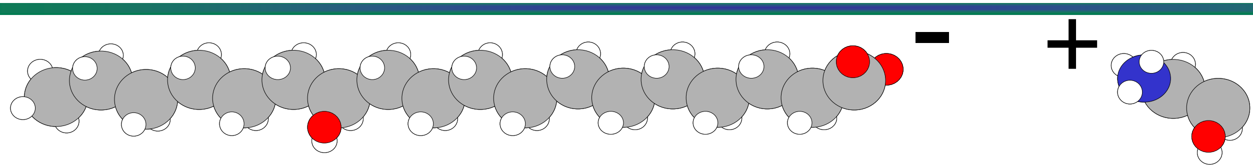
Structure of tubes at the air/water interface?



foam

Foaming properties of tubes

# Why the tubes diameter varies with the temperature?

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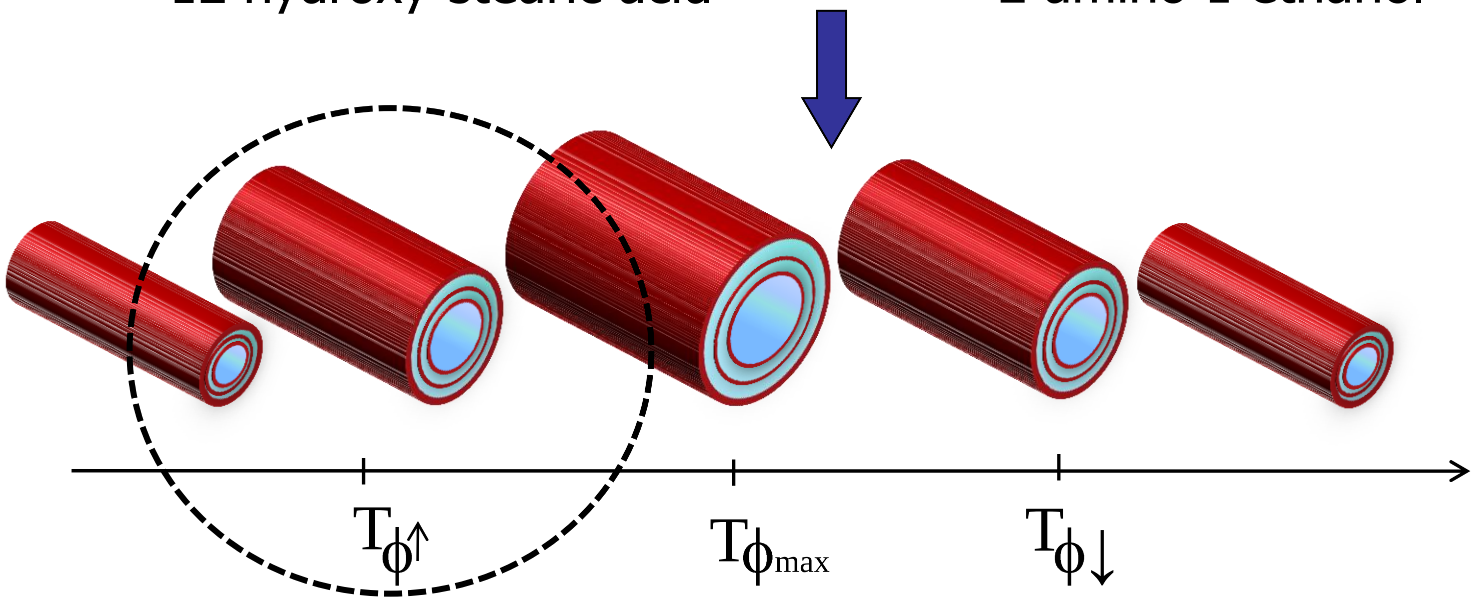
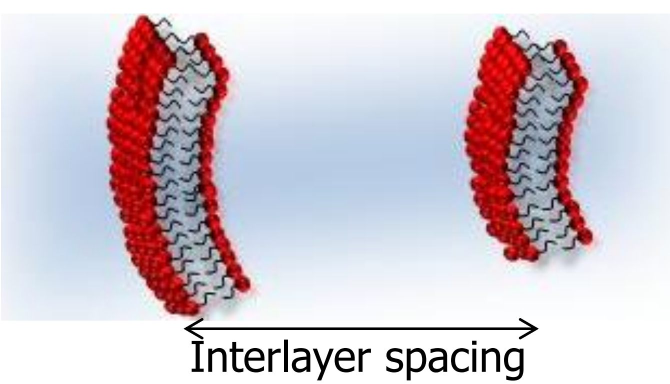
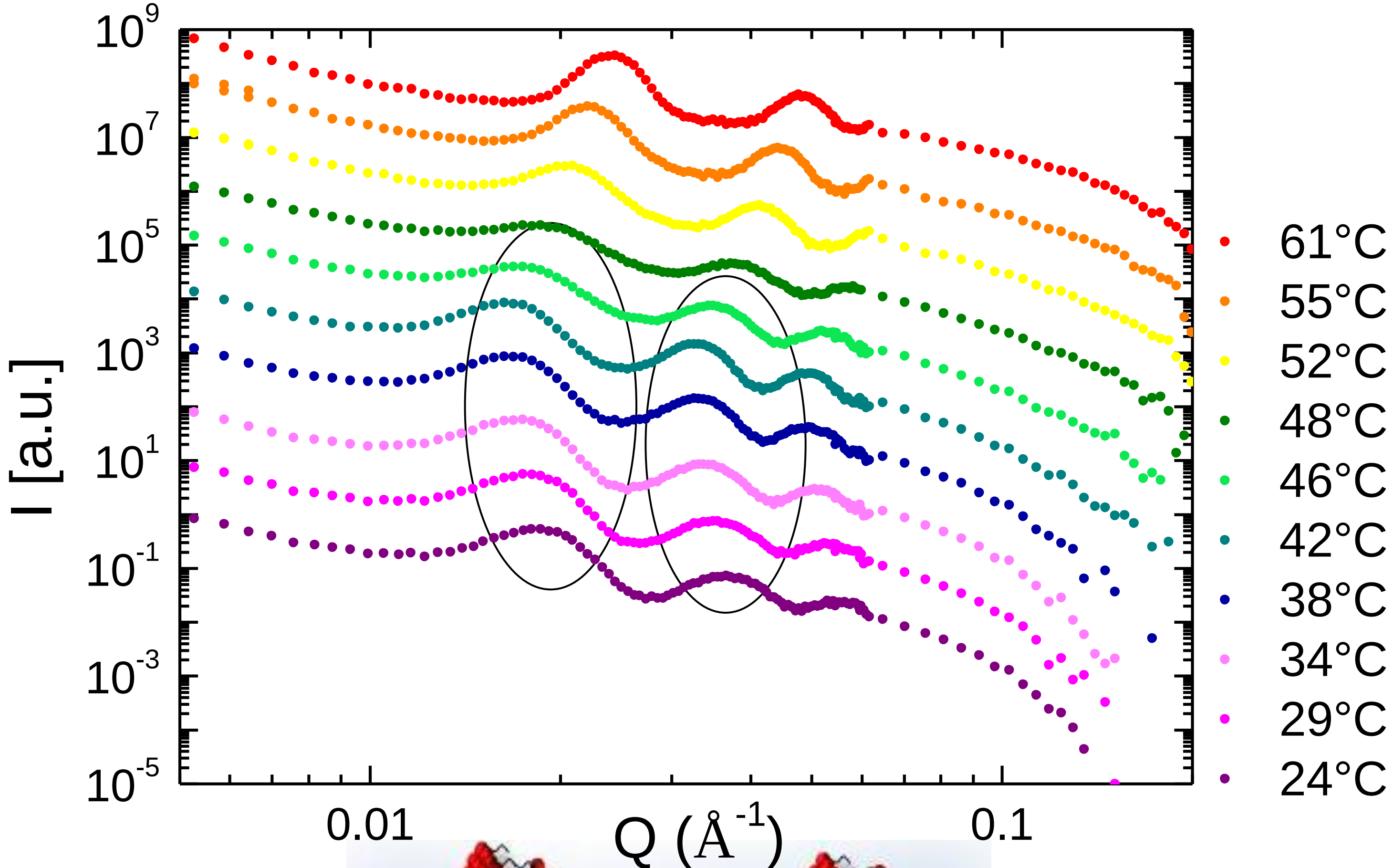
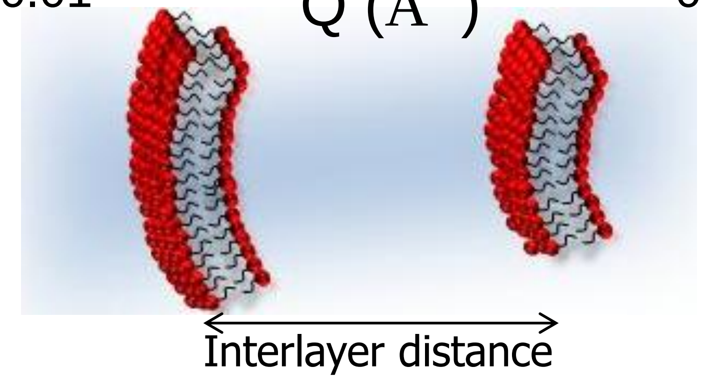



Link with an increase of the interlayer spacing?

# Characterization of the local structure by SANS



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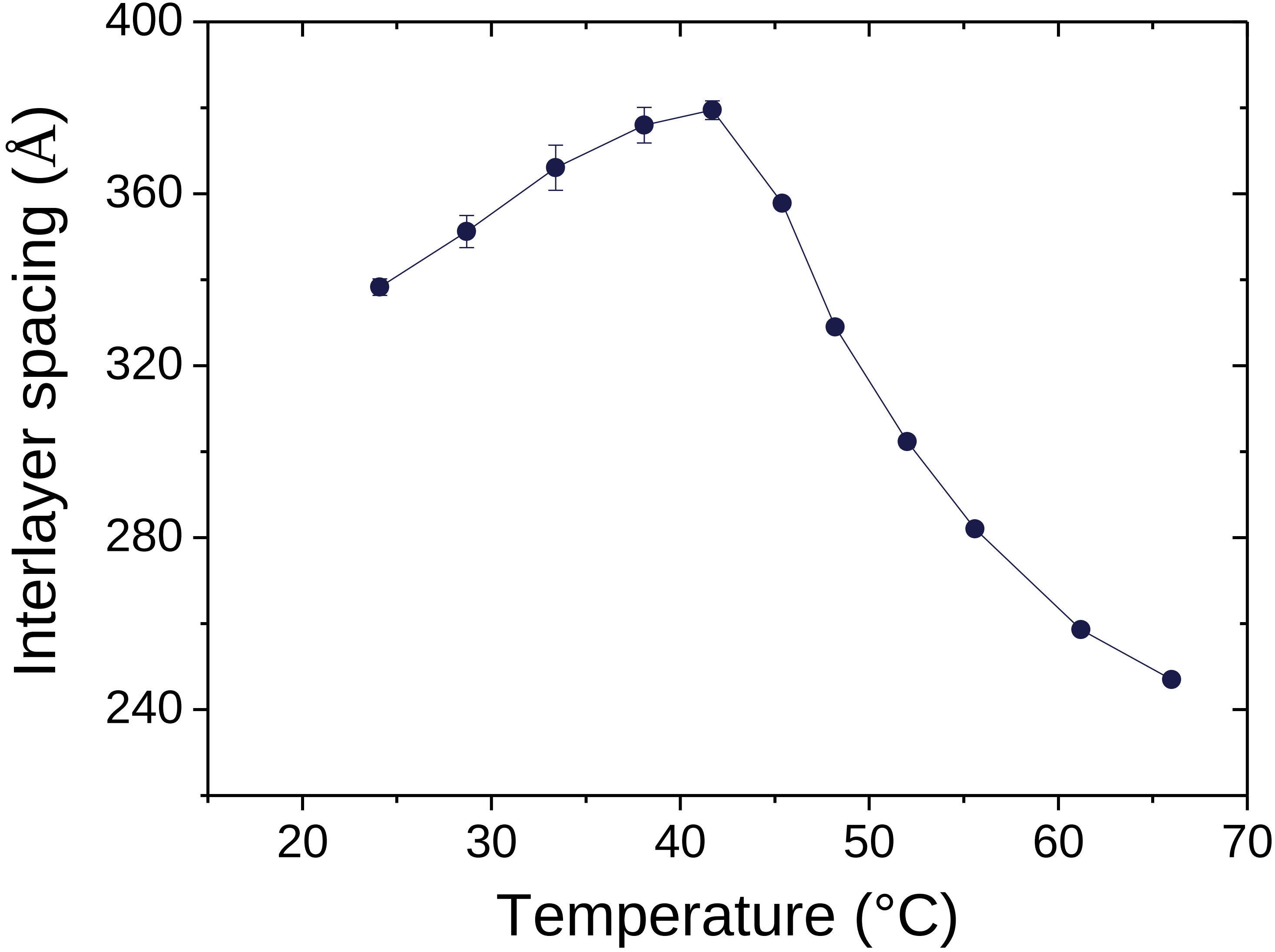
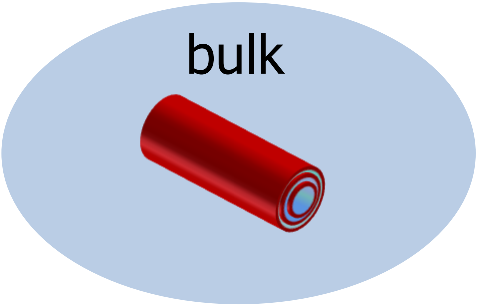
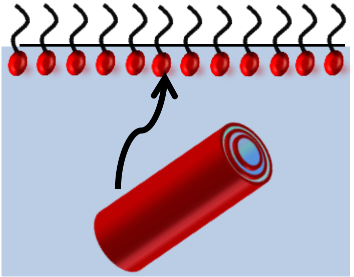



Link : structure at the local scale and at the microscopic scale

# Outline

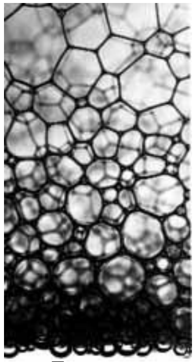



Presentation of the system in bulk



interface

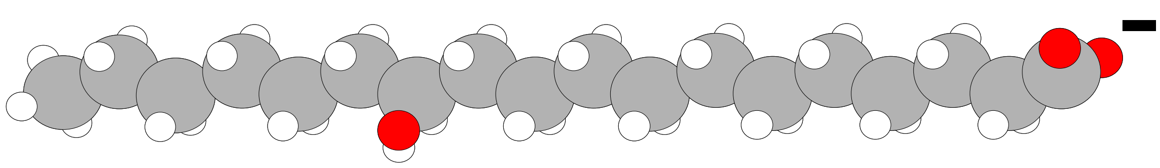
Structure of tubes at the air/water interface?



foam

Foaming properties of tubes

# Structure at the interface?



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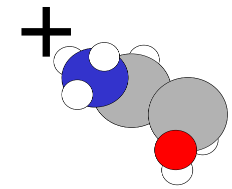

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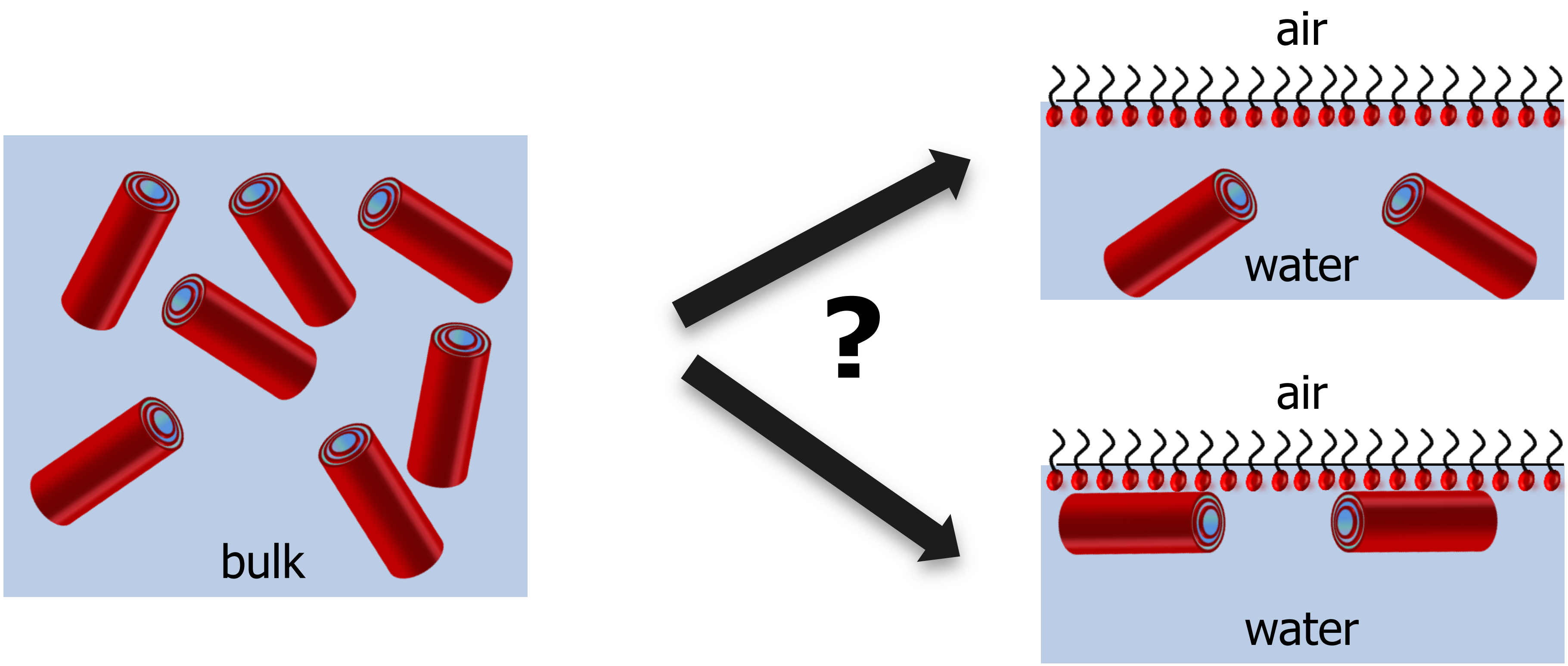
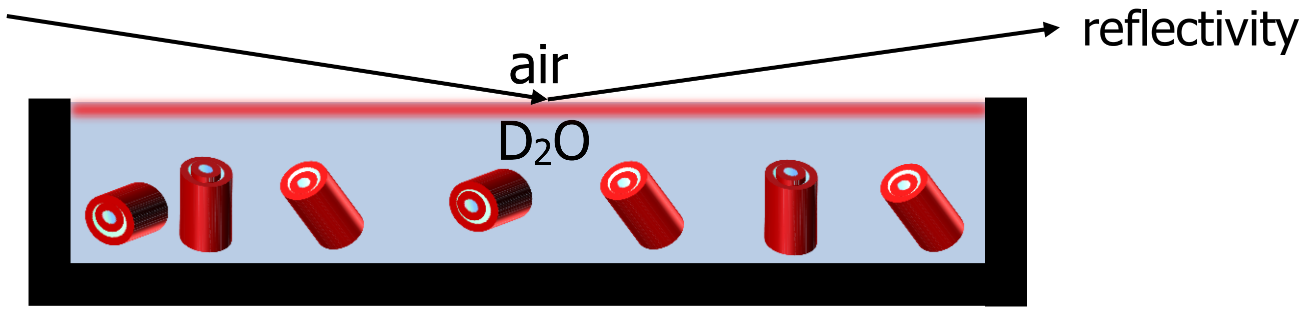
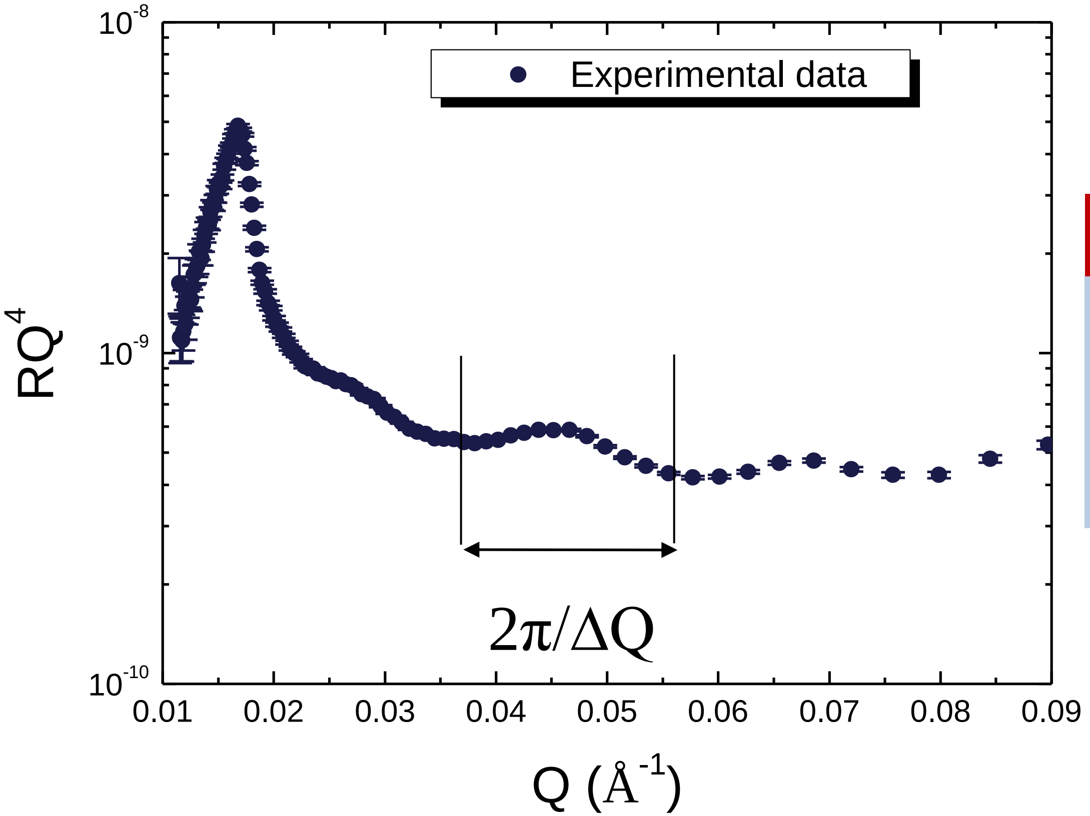
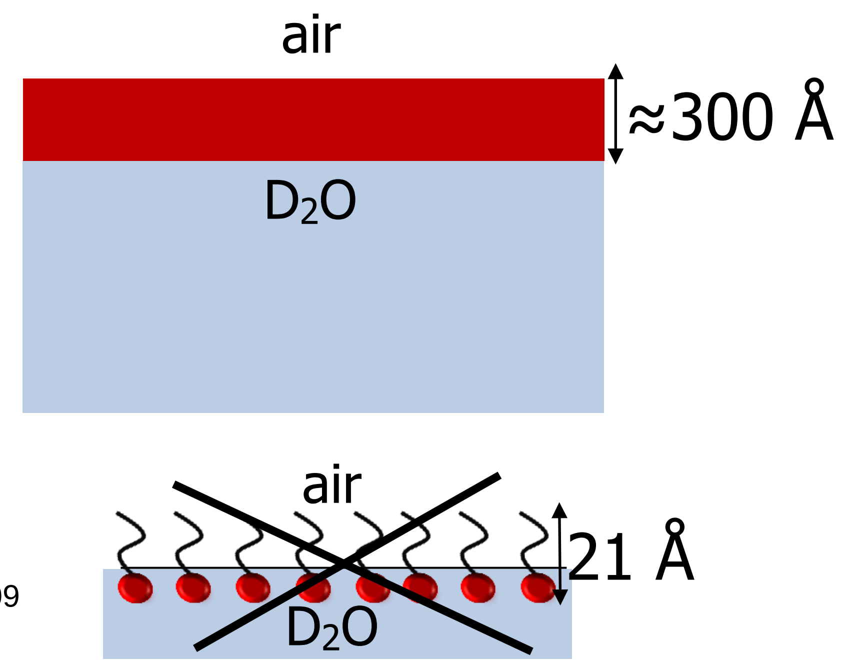



Adsorption of tubes at the air/water interface?

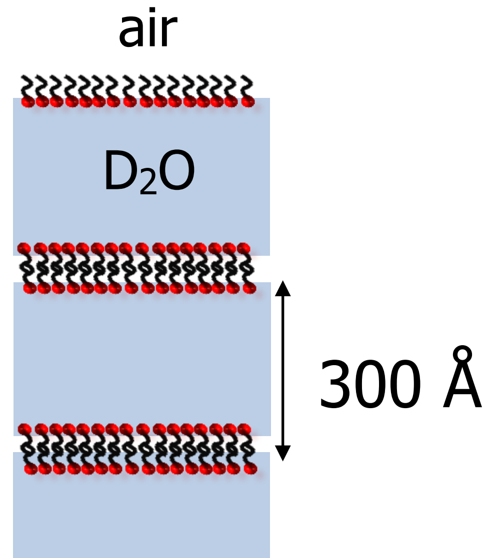
# Neutron Reflectivity

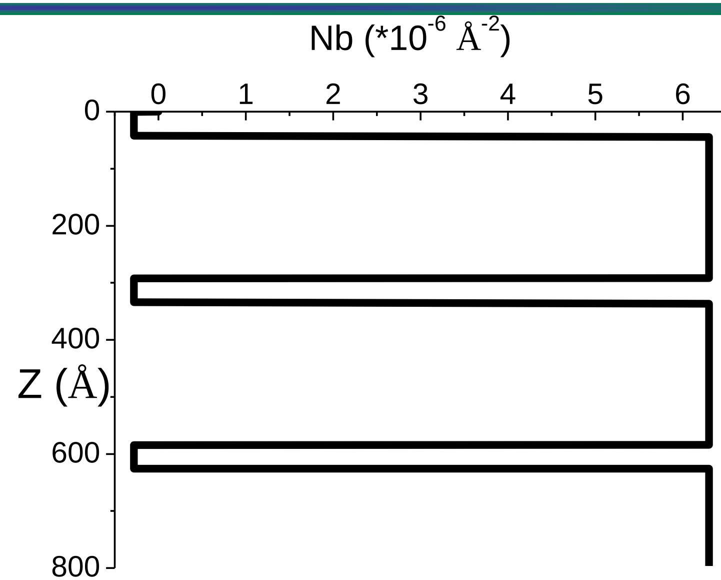


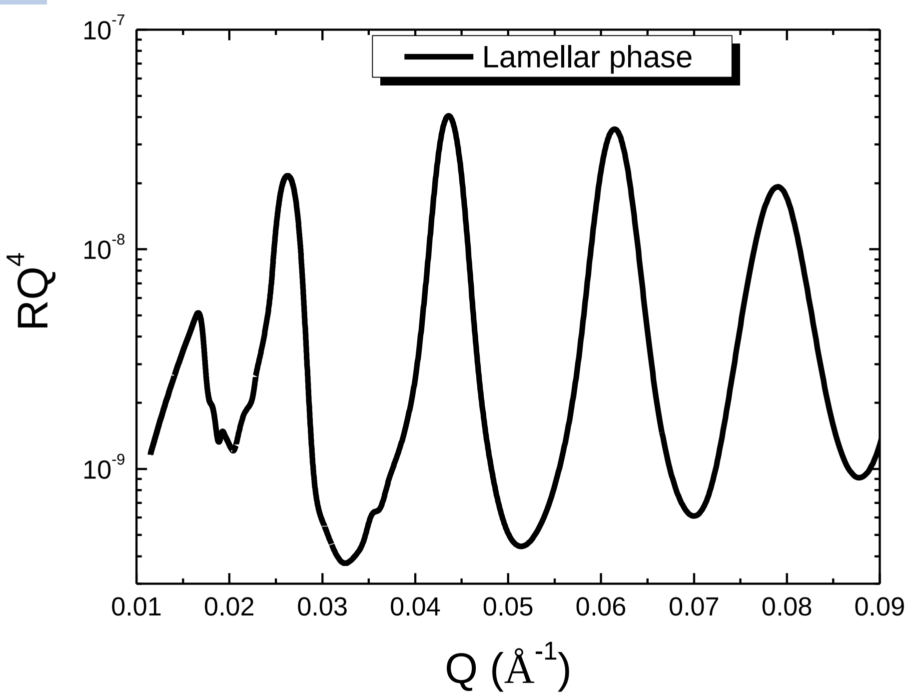



# Simple models to explain the results ?



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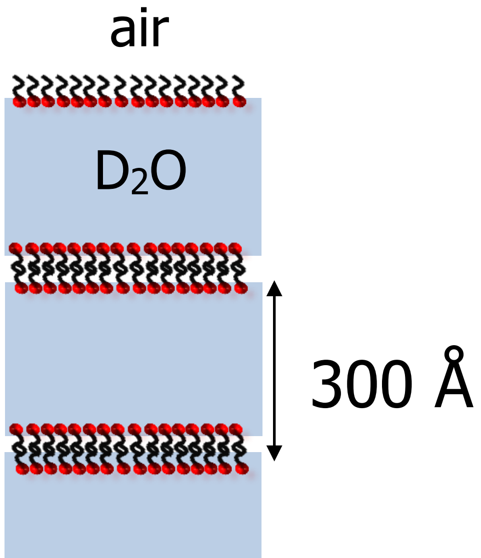


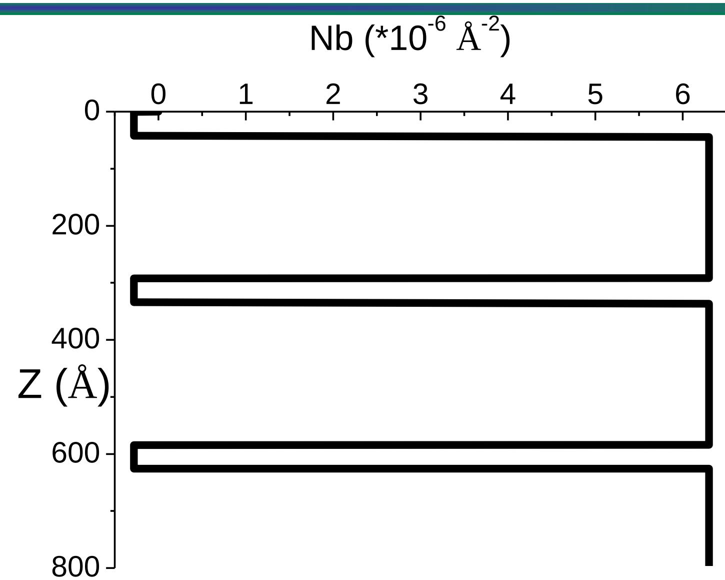


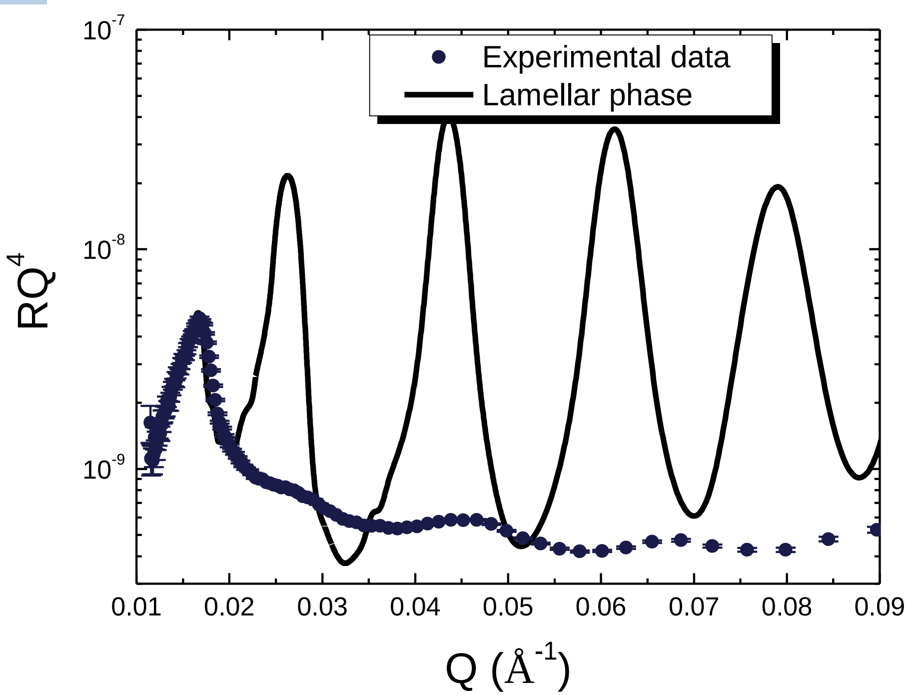

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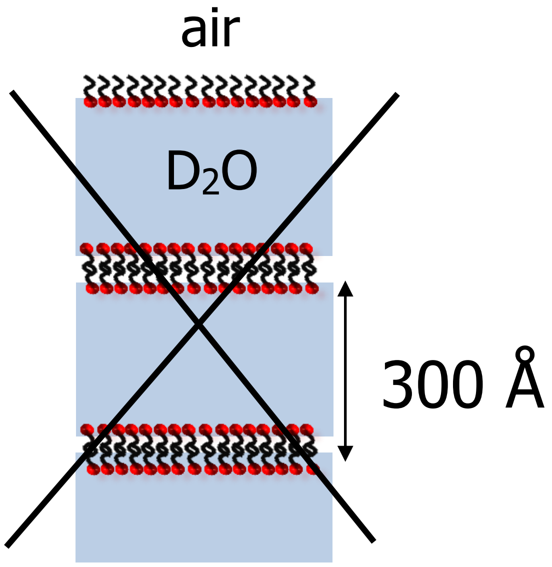
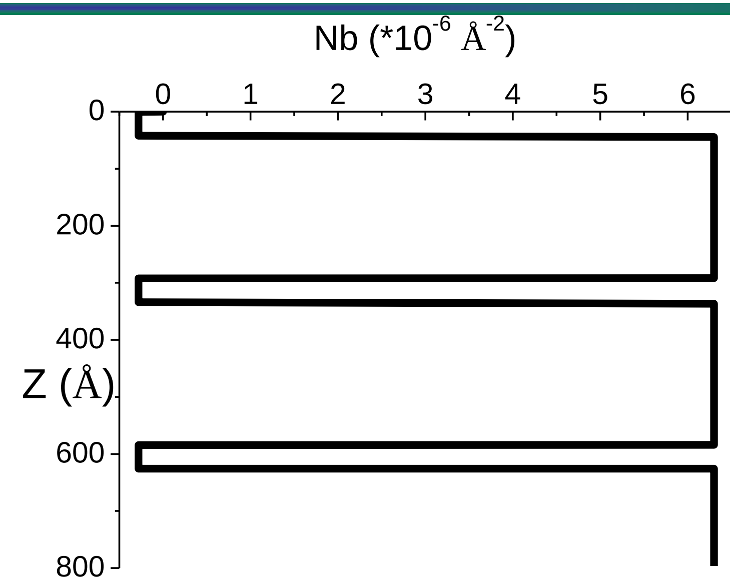
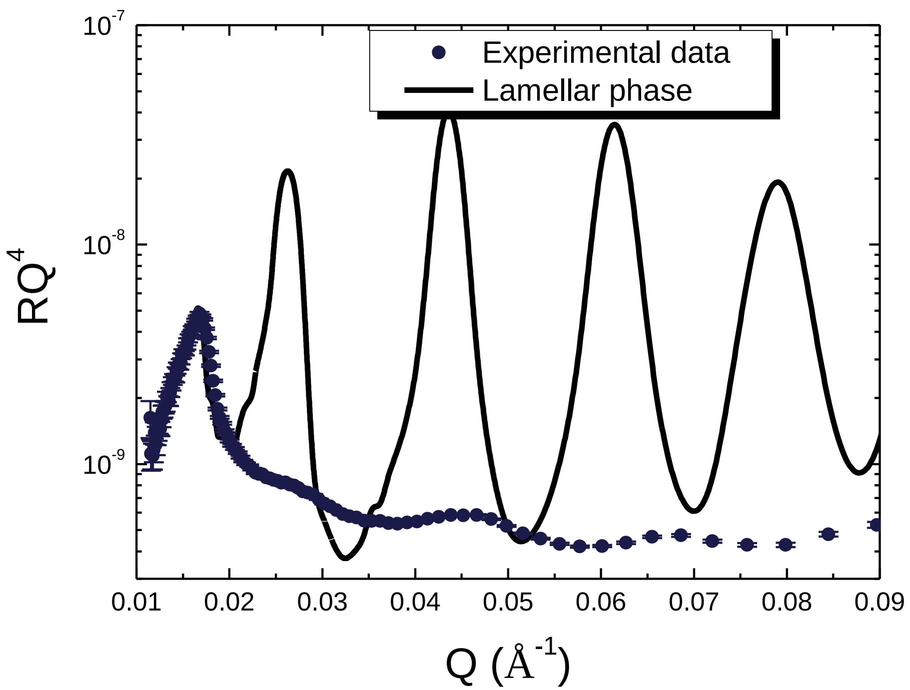
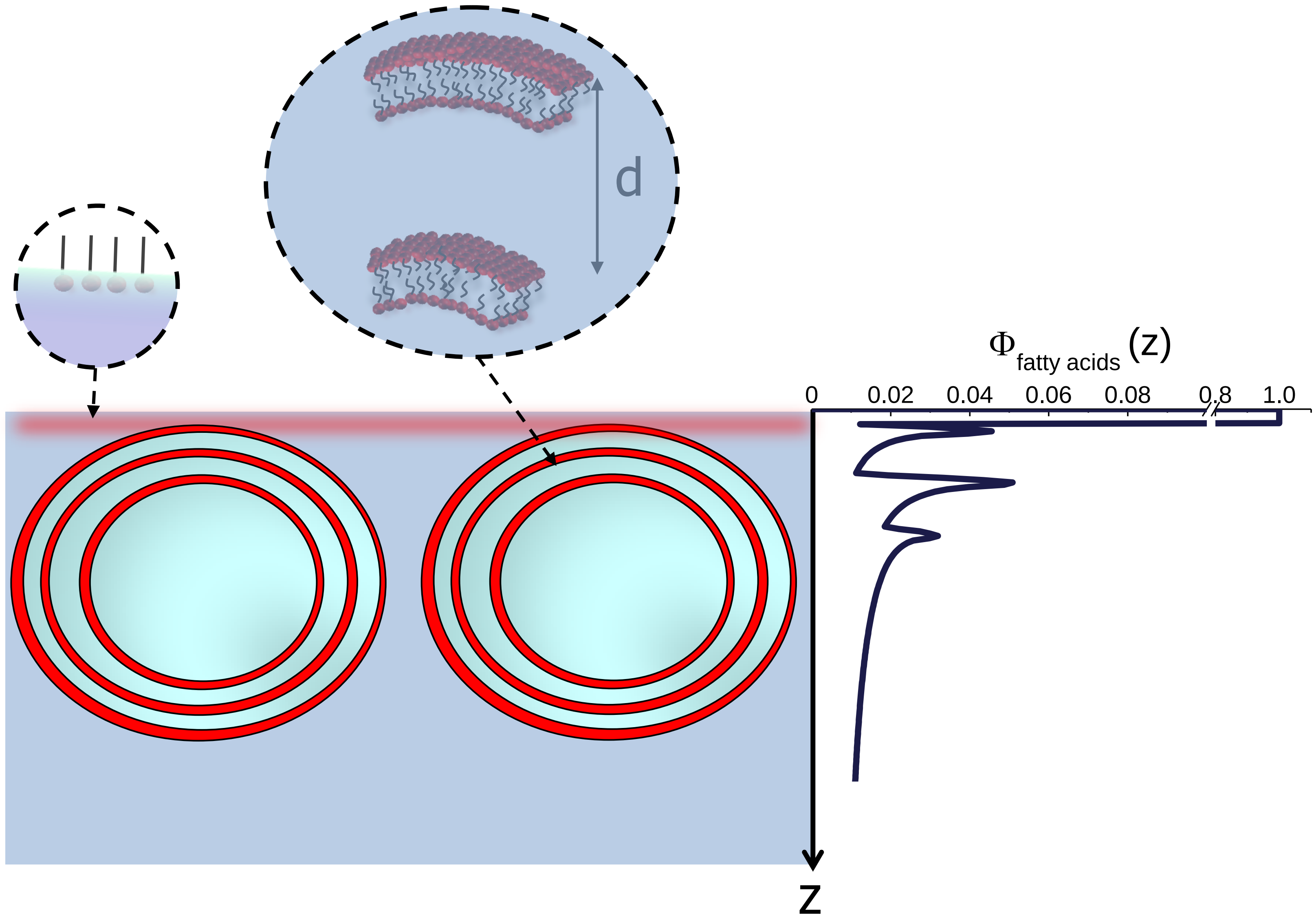


# Model of adsorbed tubes at the interface



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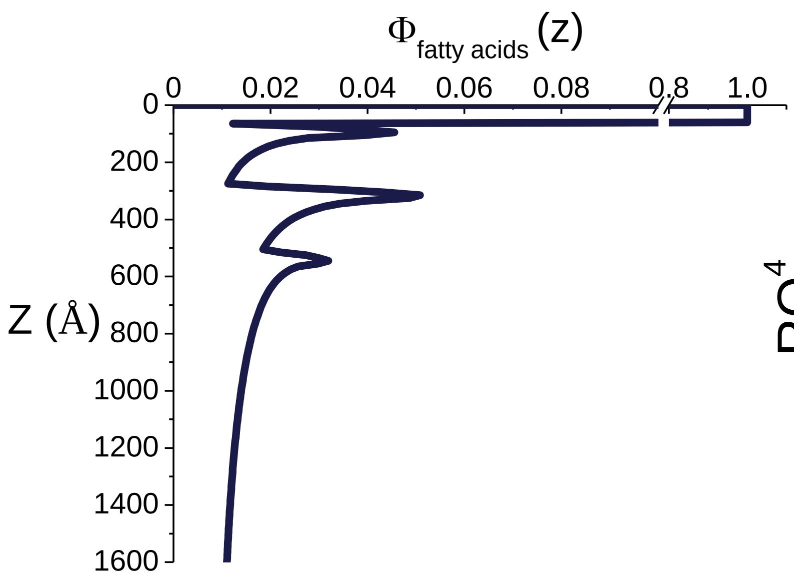


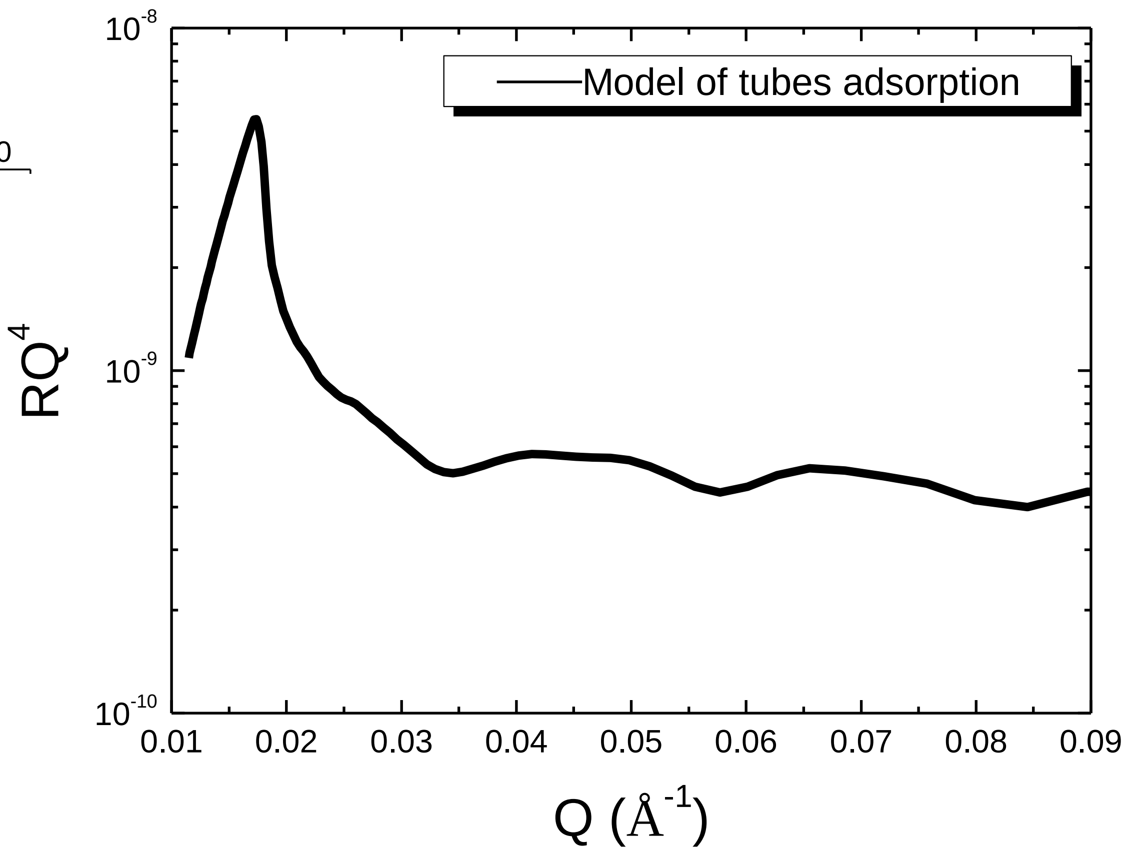

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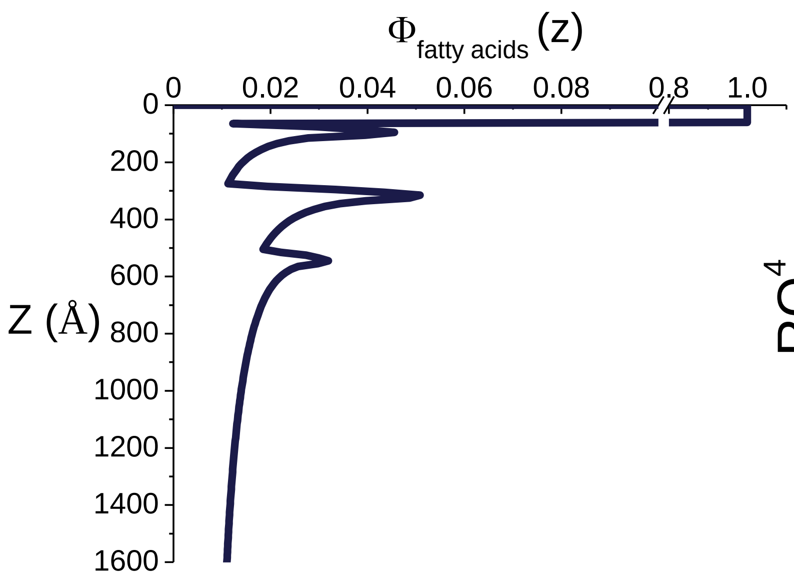
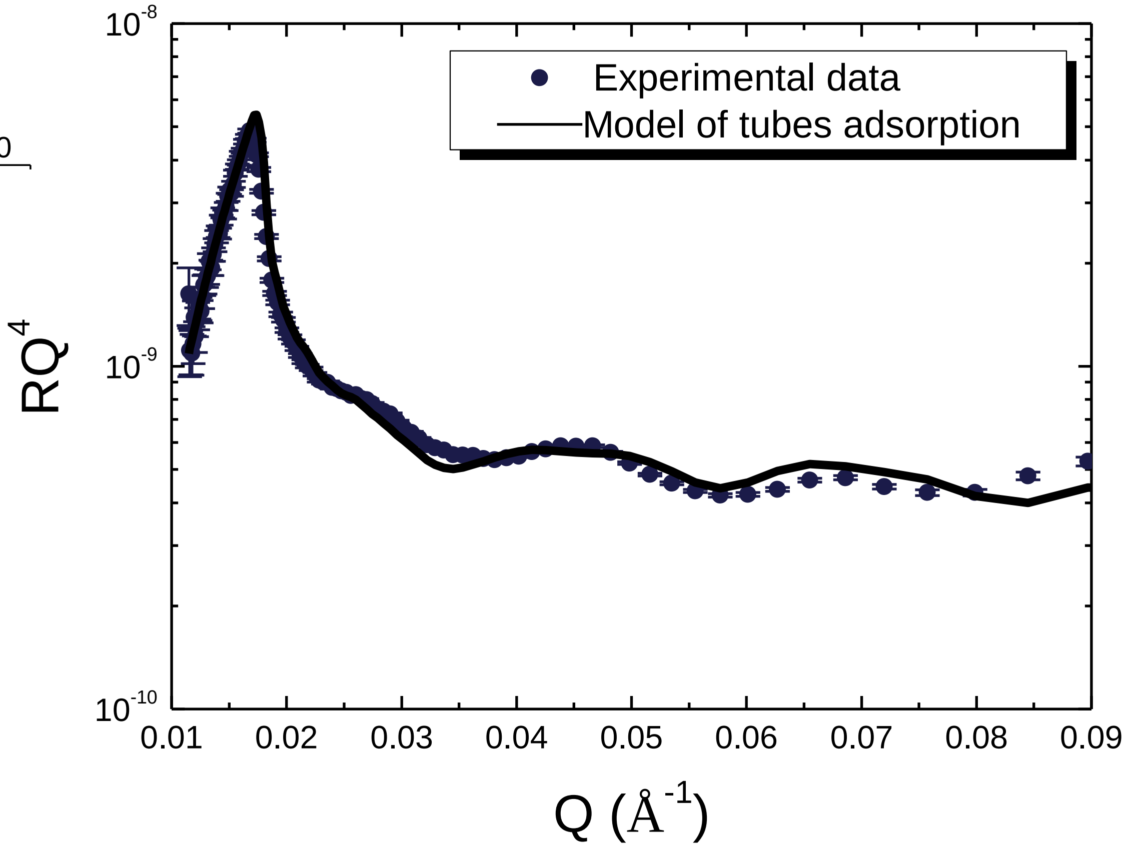
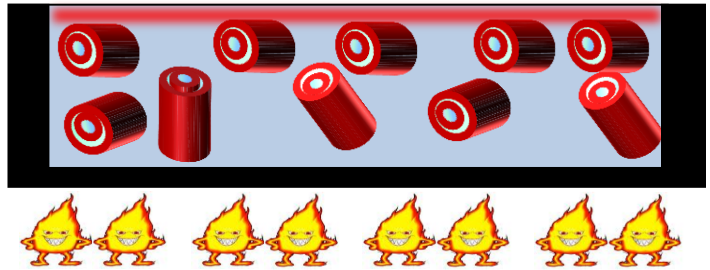
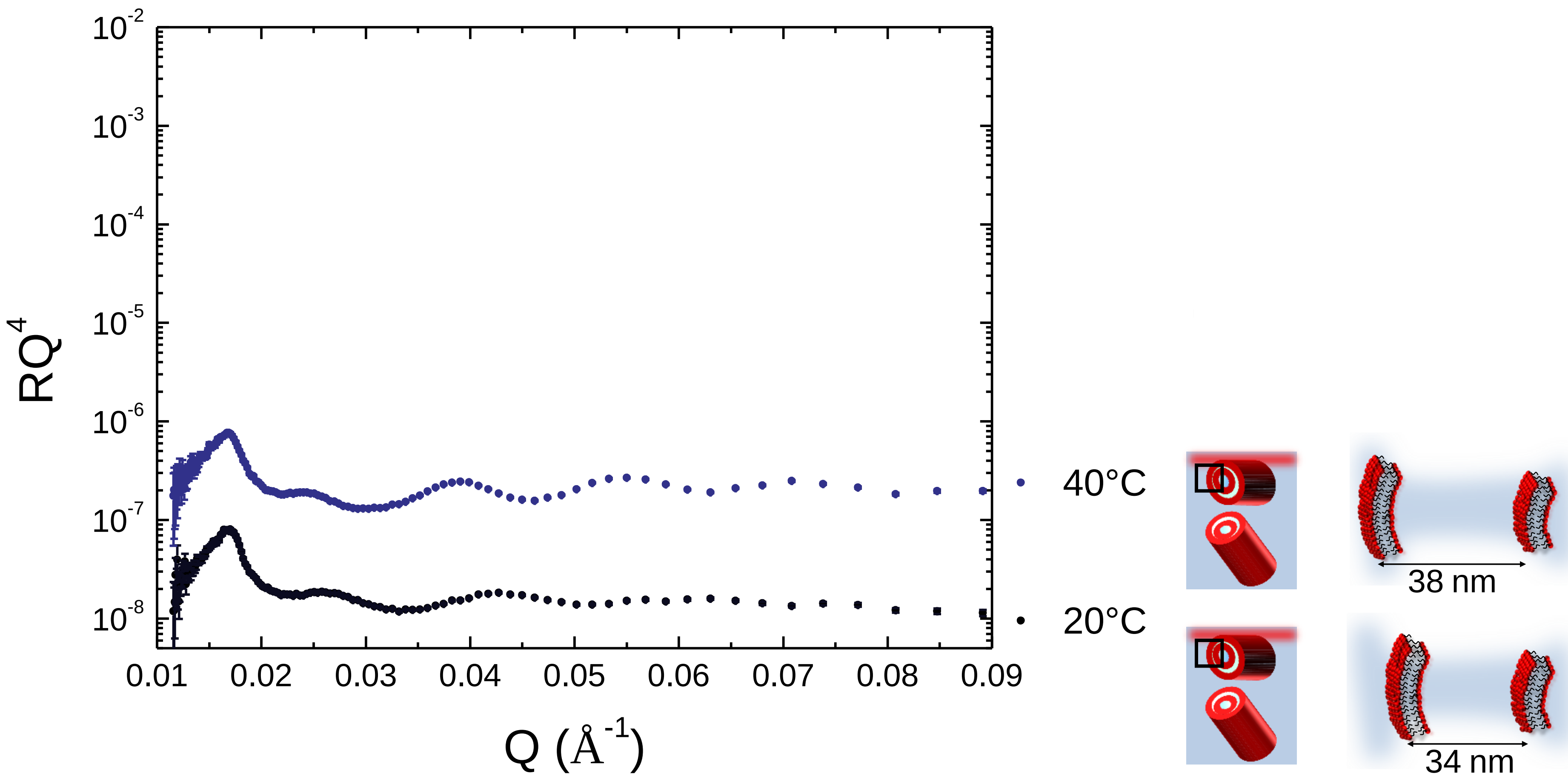



Adsorption of tubes at the air/water interface!

# Evolution with the temperature





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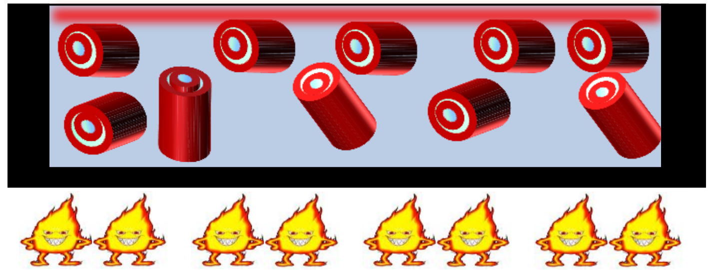

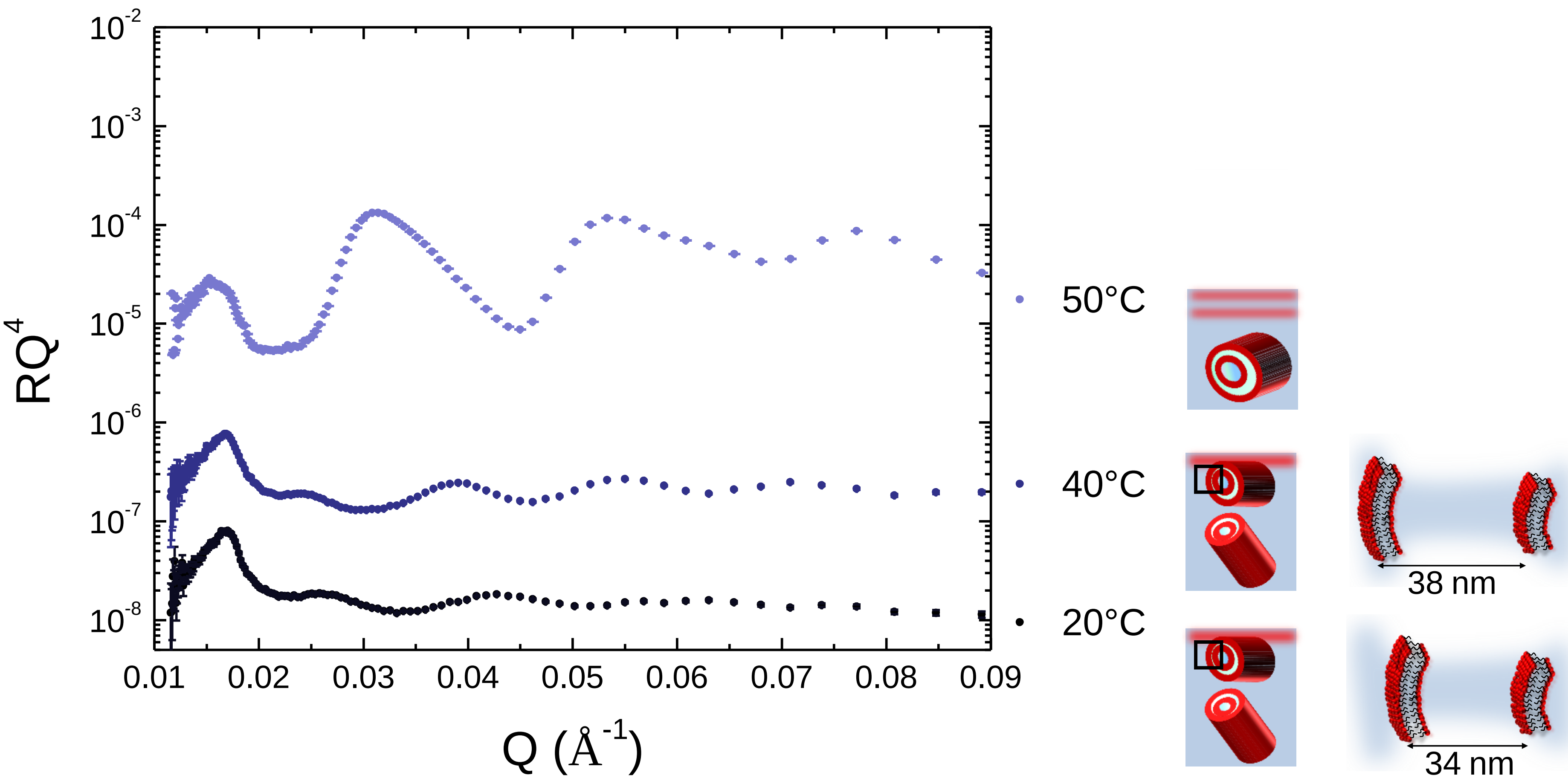

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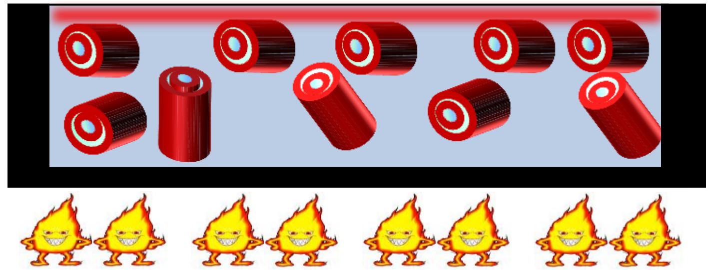

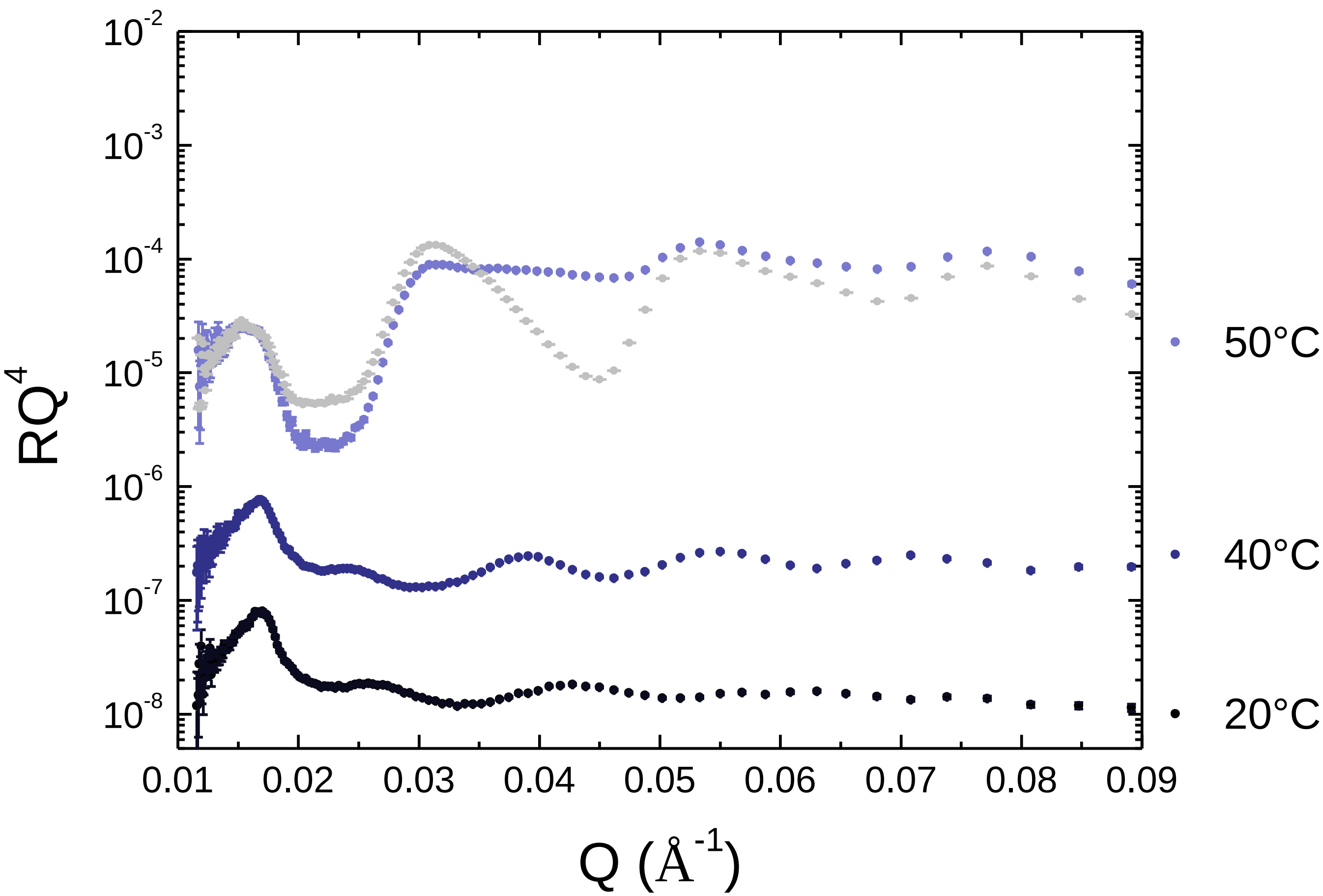


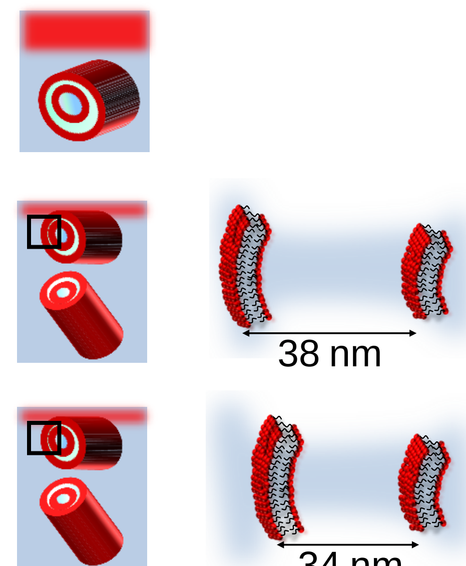

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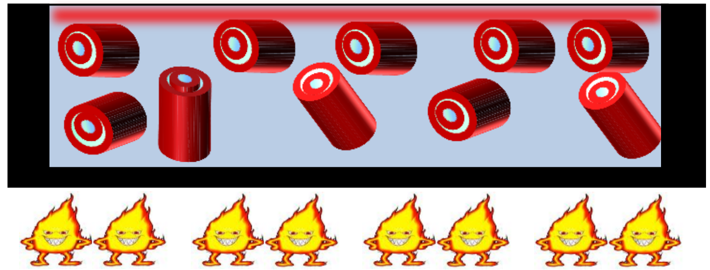

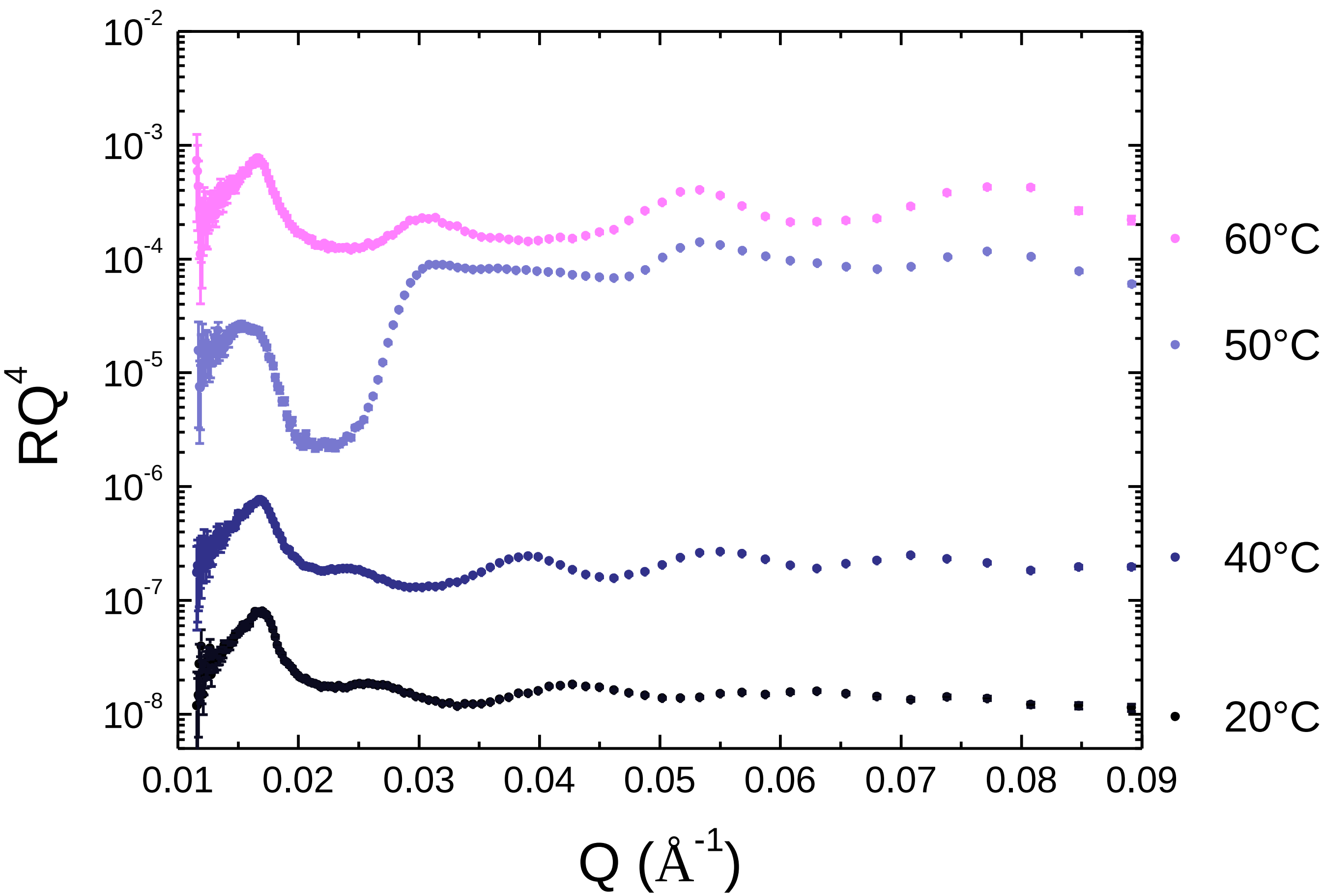


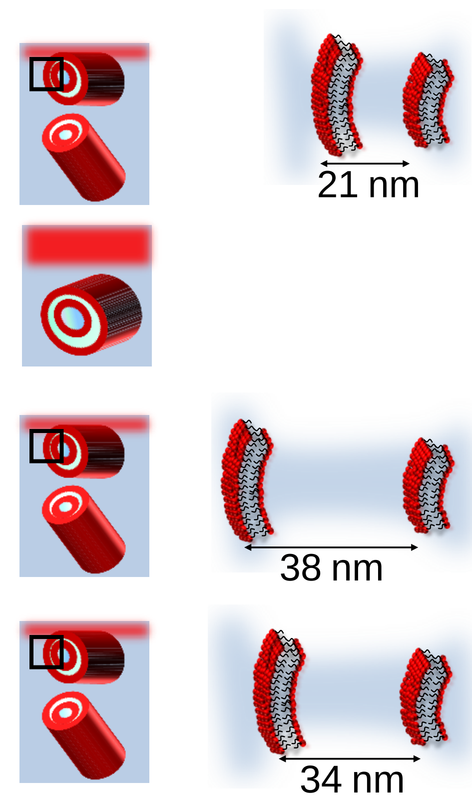

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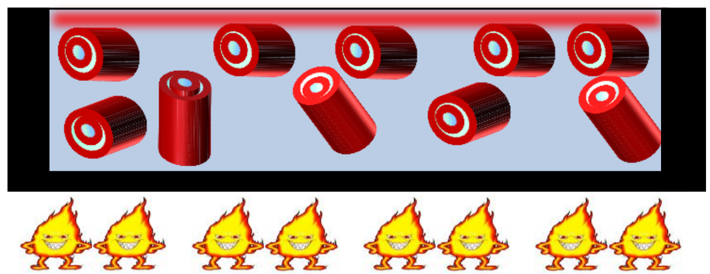
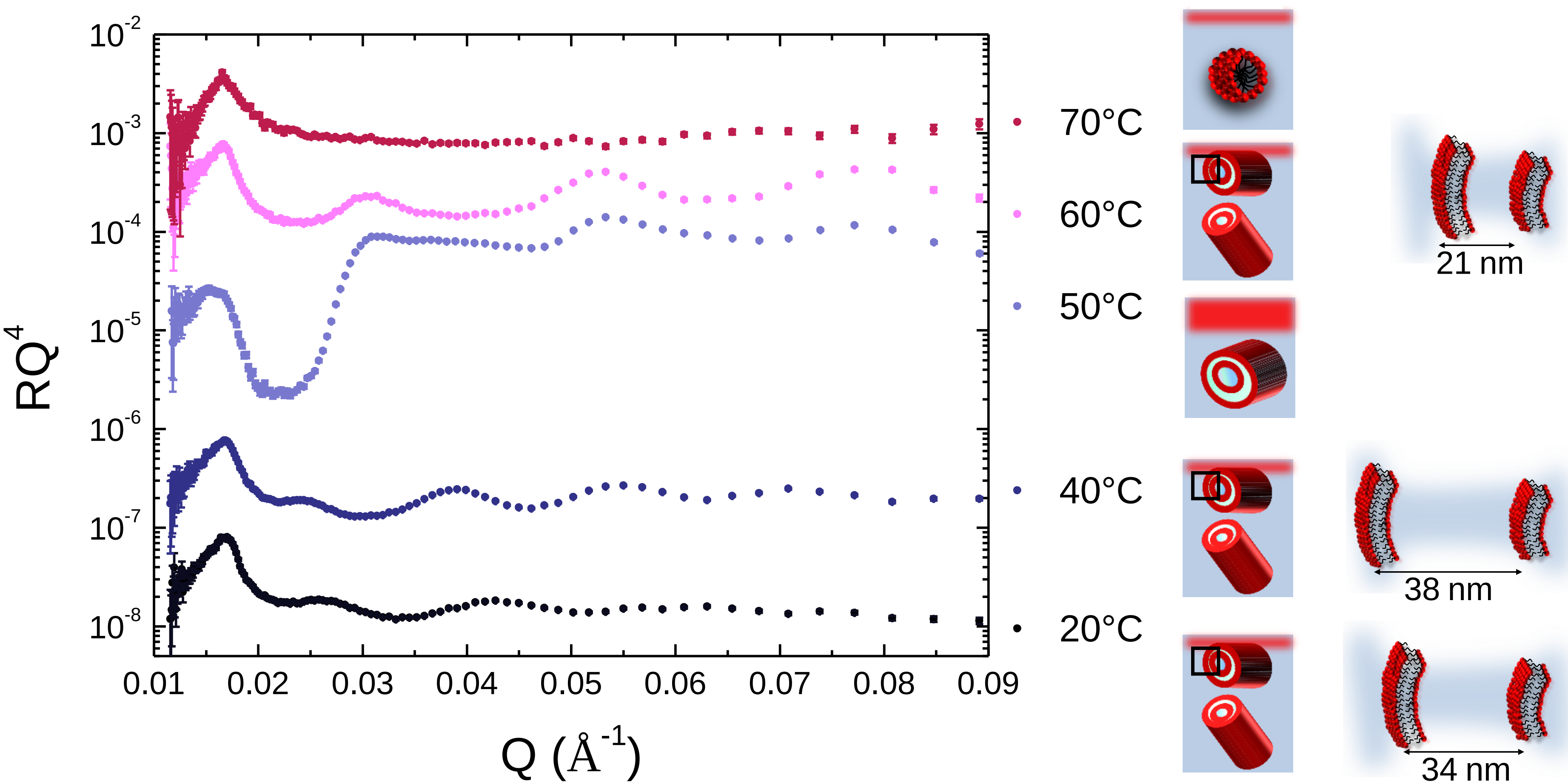
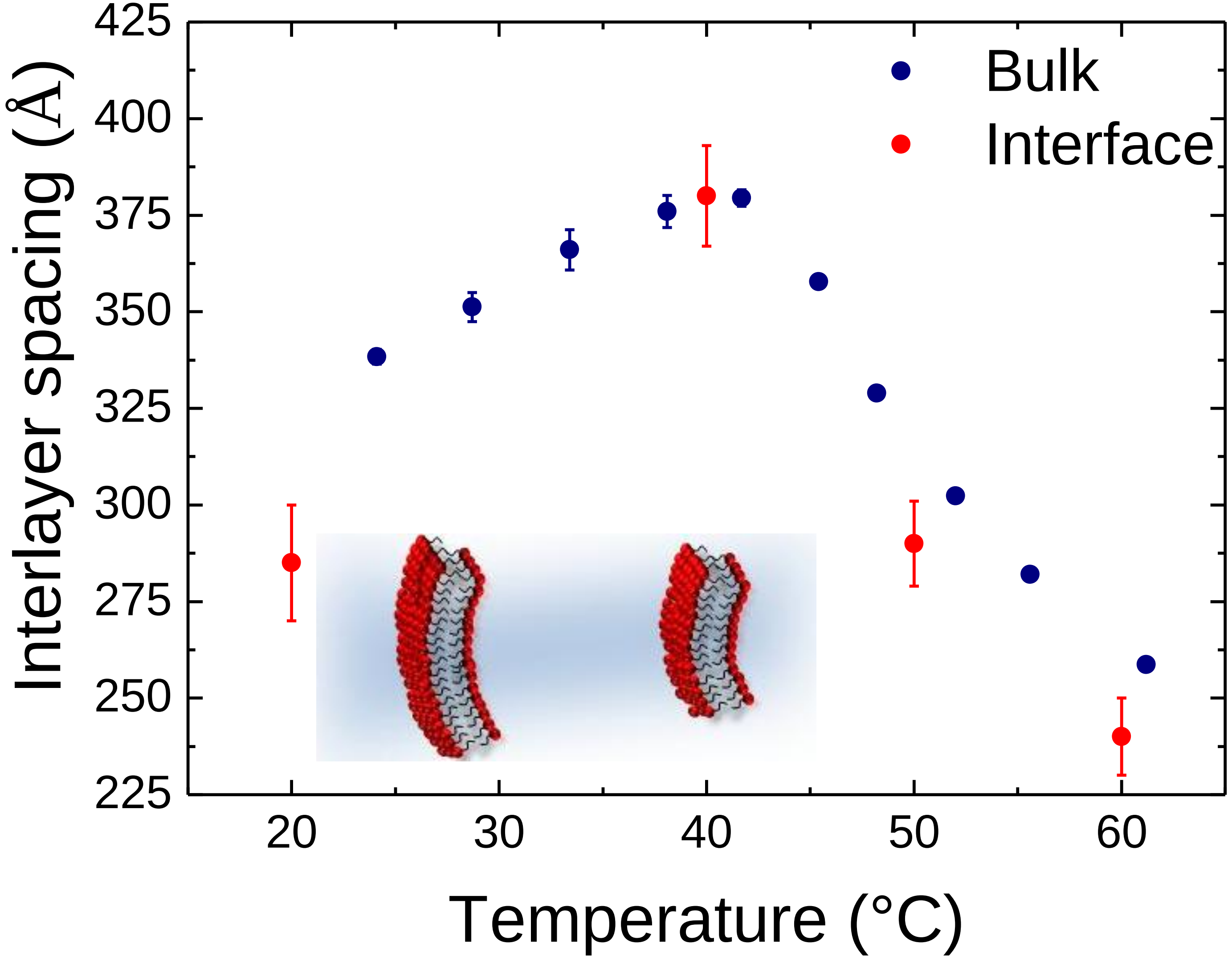


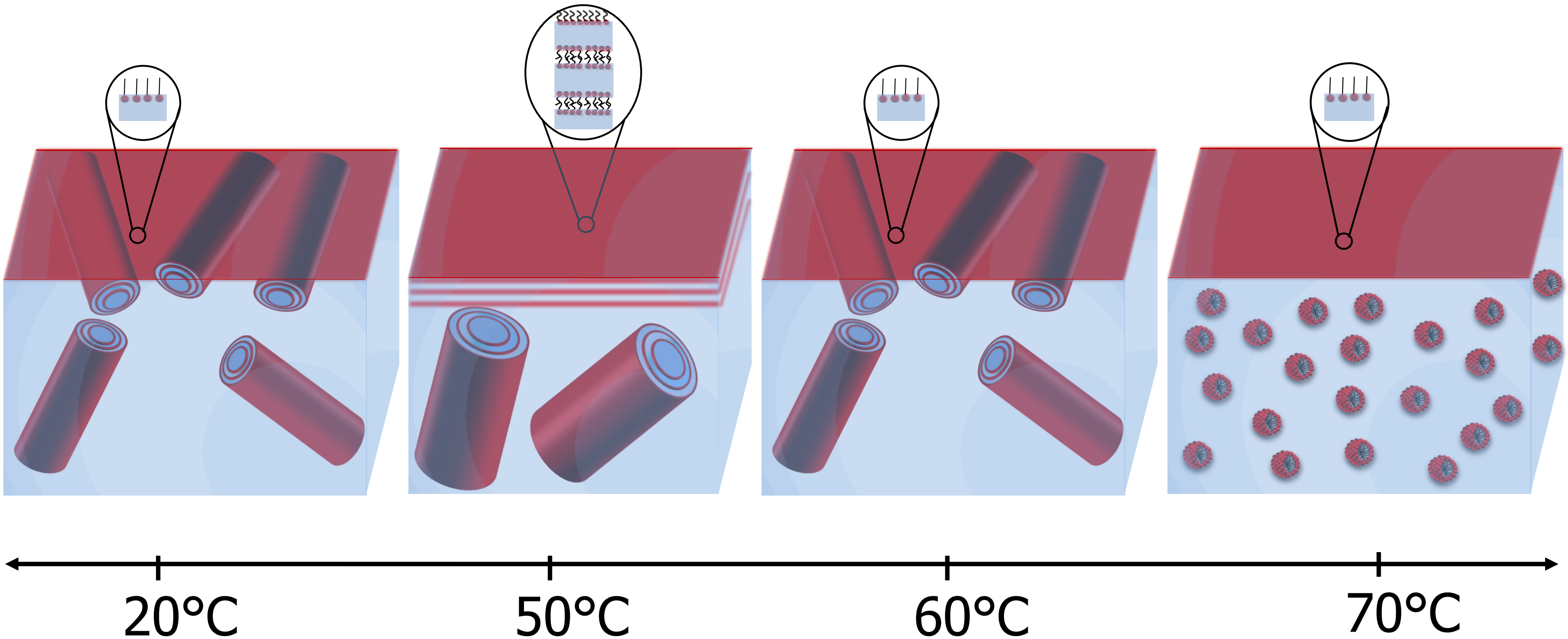


# Comparison structure in bulk and at the interface




Same evolution of the interlayer spacing

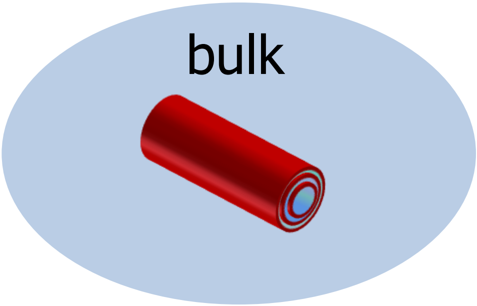
# Comparison structure in bulk and at the interface



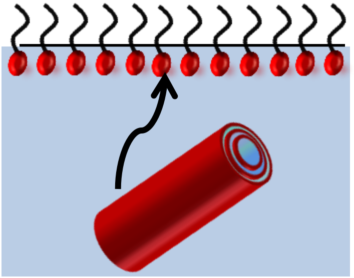

Structure at the interface temperature tunable!

Fameau A.L., Douliez J.P. , Boué F., Ott F. & Cousin F., (2011) Journal of colloid and Interface Science, 362, 397-405.

# Outline

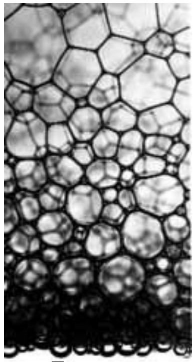



Presentation of the system in bulk



interface

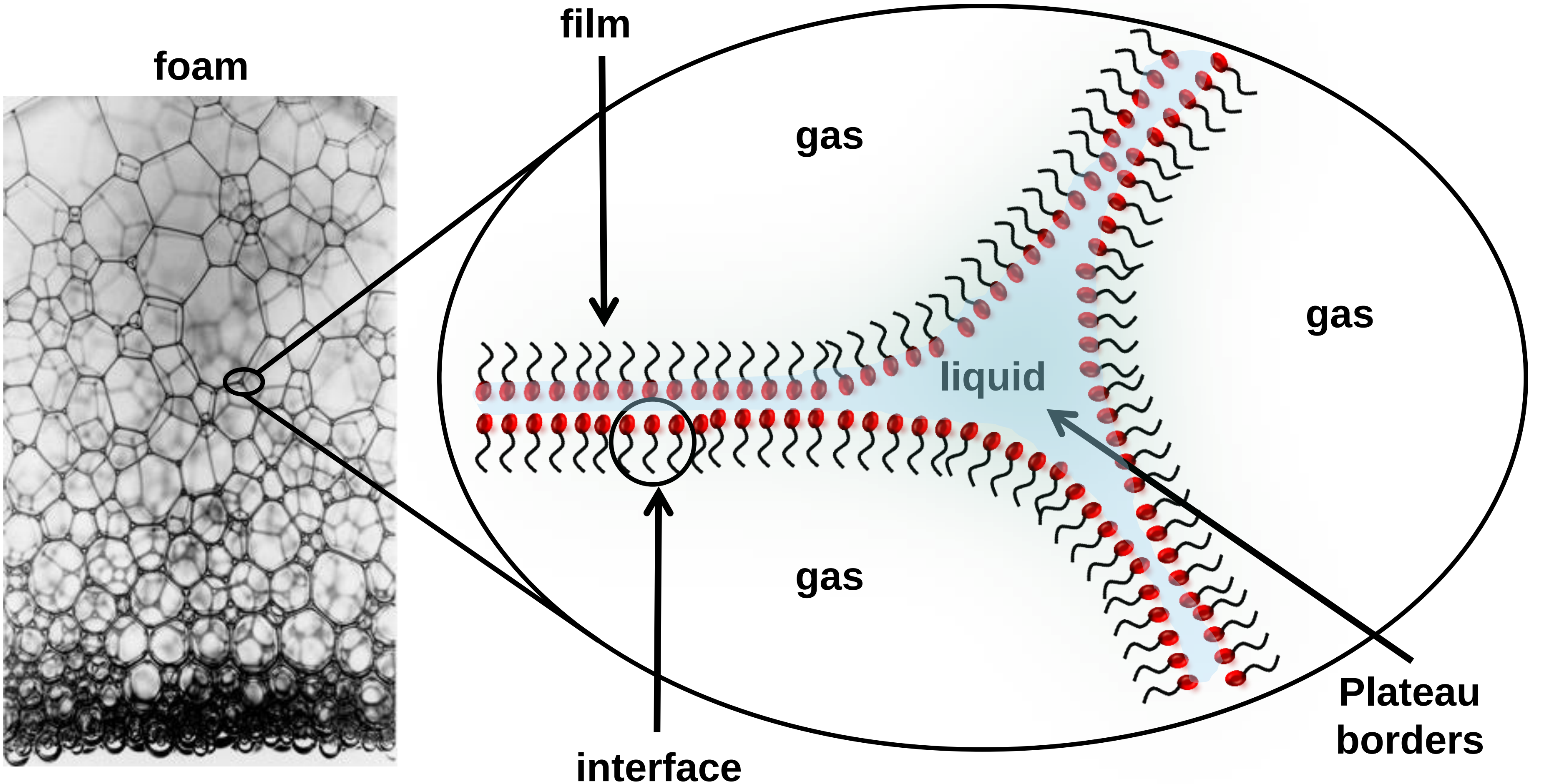
Structure of tubes at the air/water interface?



foam

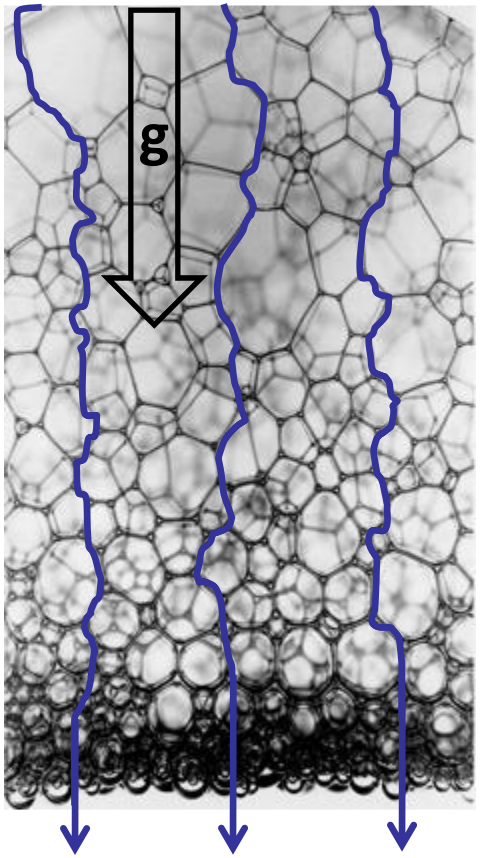
Foaming properties of tubes

# What is a foam?



# Mechanisms of foam destabilization

**drainage**



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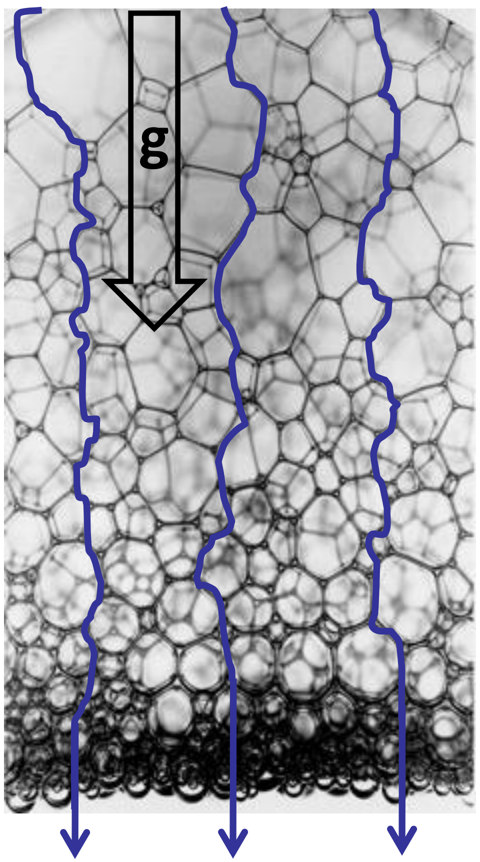
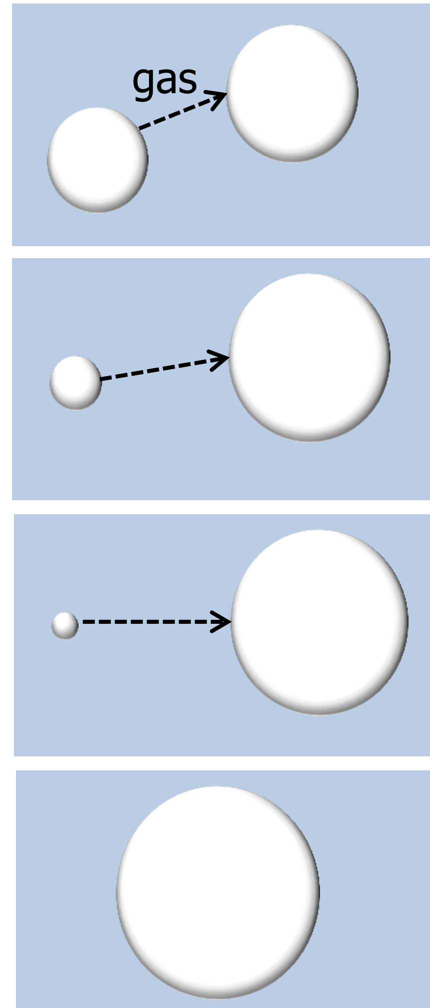
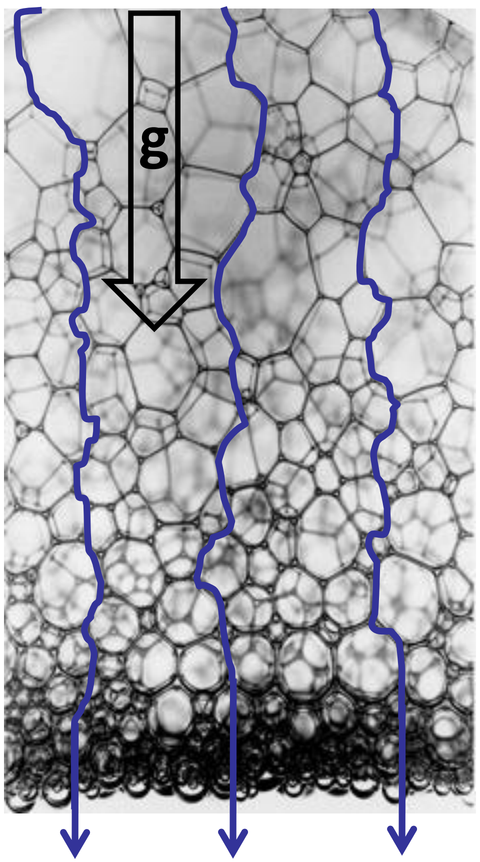



**coarsening**

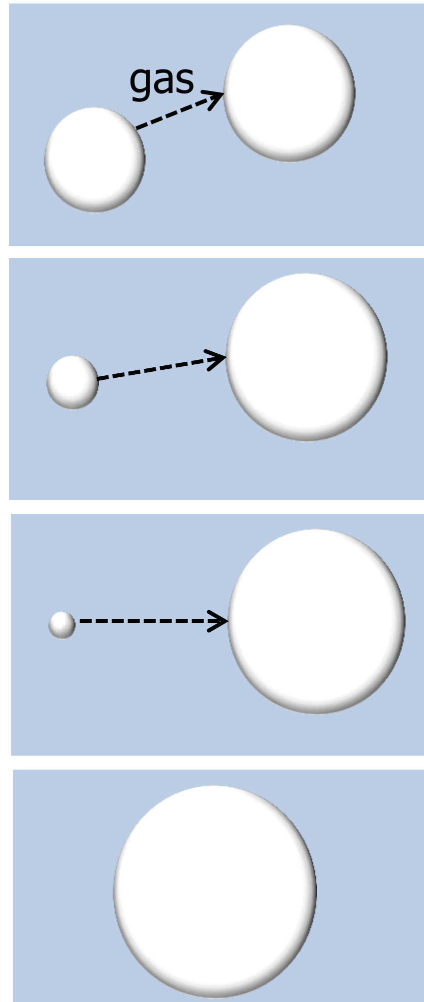


# Mechanisms of foam destabilization

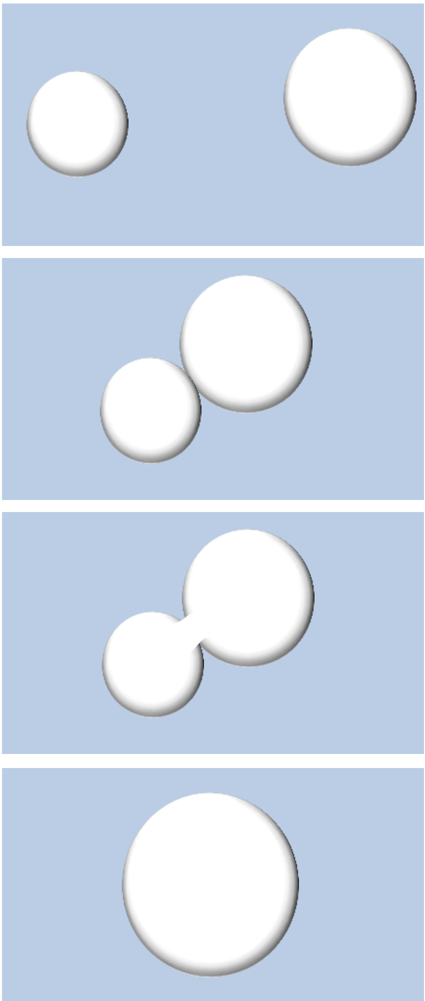
**drainage**



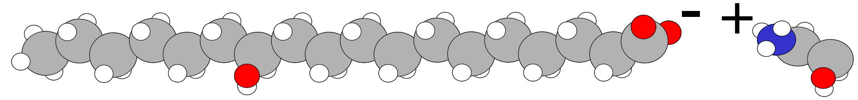

**coarsening**

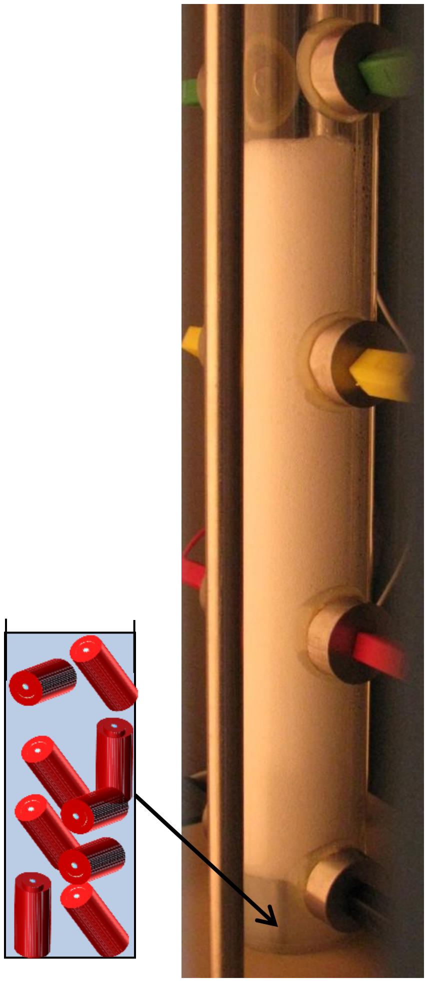



**coalescence**



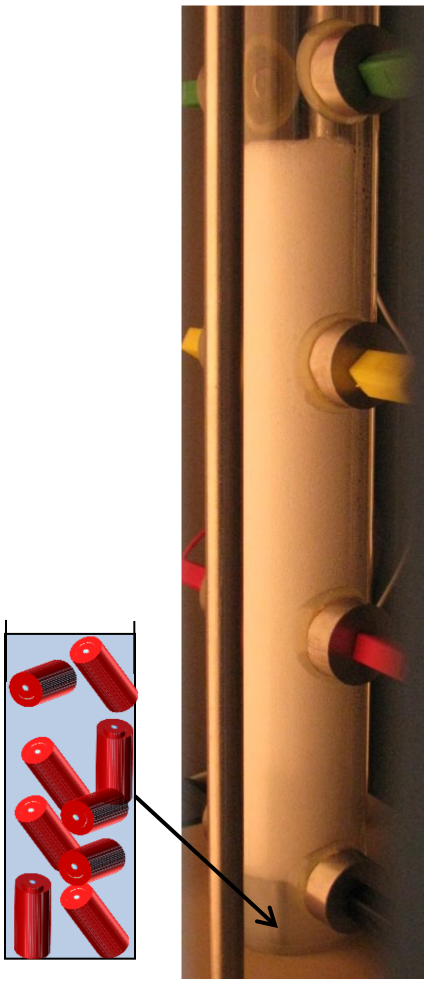
# Formation and foam stability at 25°C

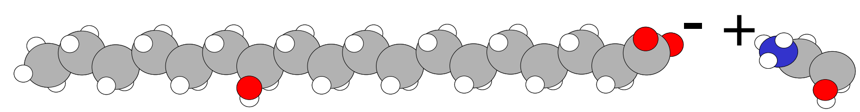


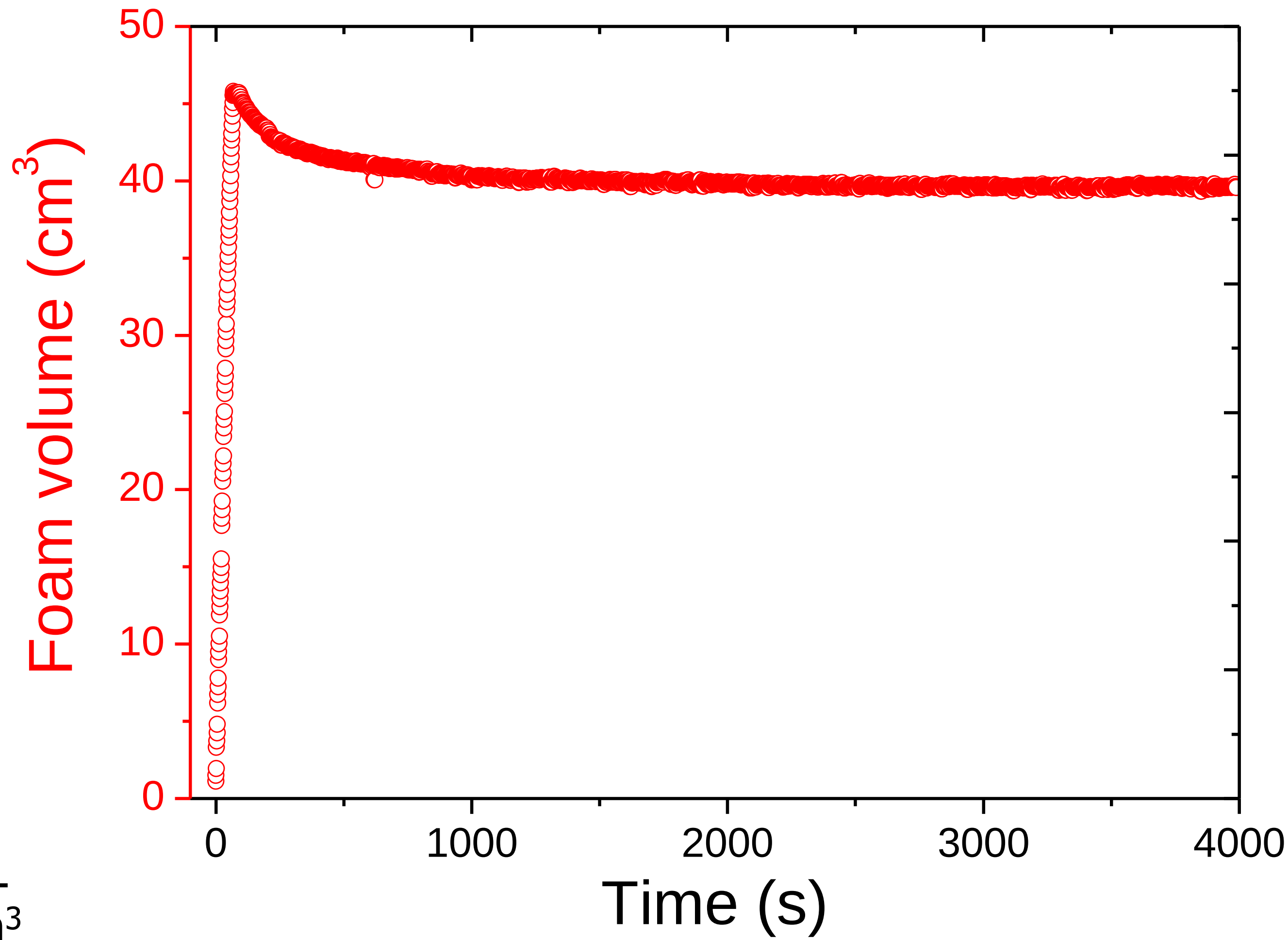



Concentration: 10 g/L
Flow rate =35 mL/cm$^3$

# Formation and foam stability at 25°C

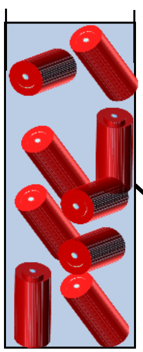


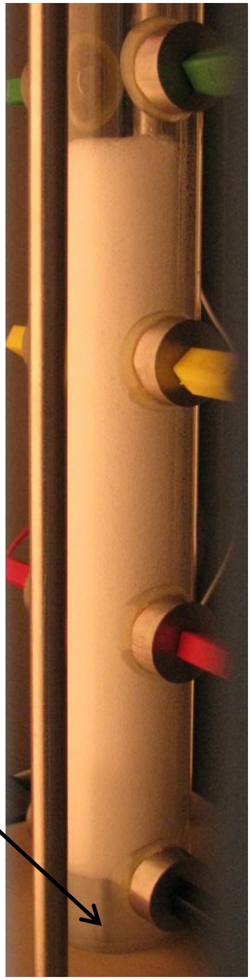


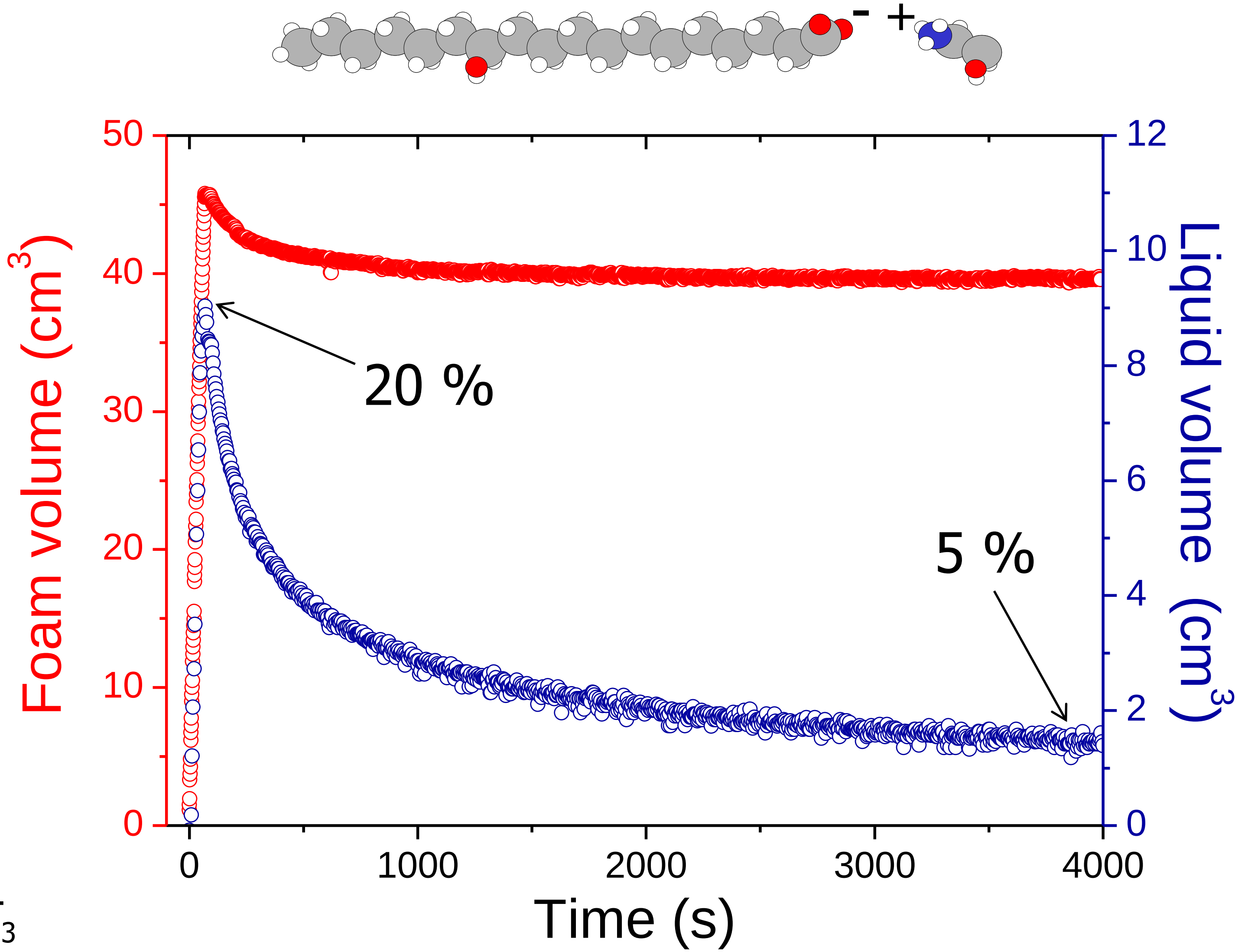




Concentration: 10 g/L
Flow rate =35 mL/cm$^3$

# Formation and foam stability at 25°C

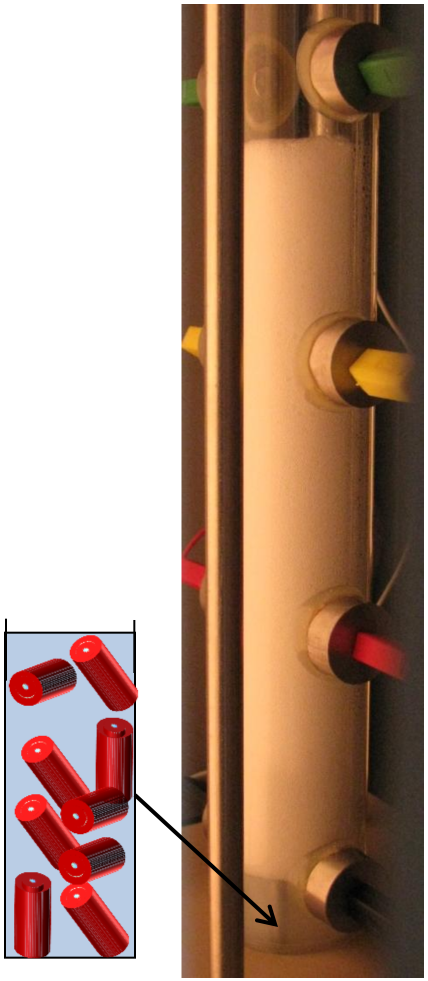


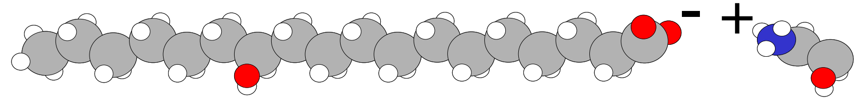


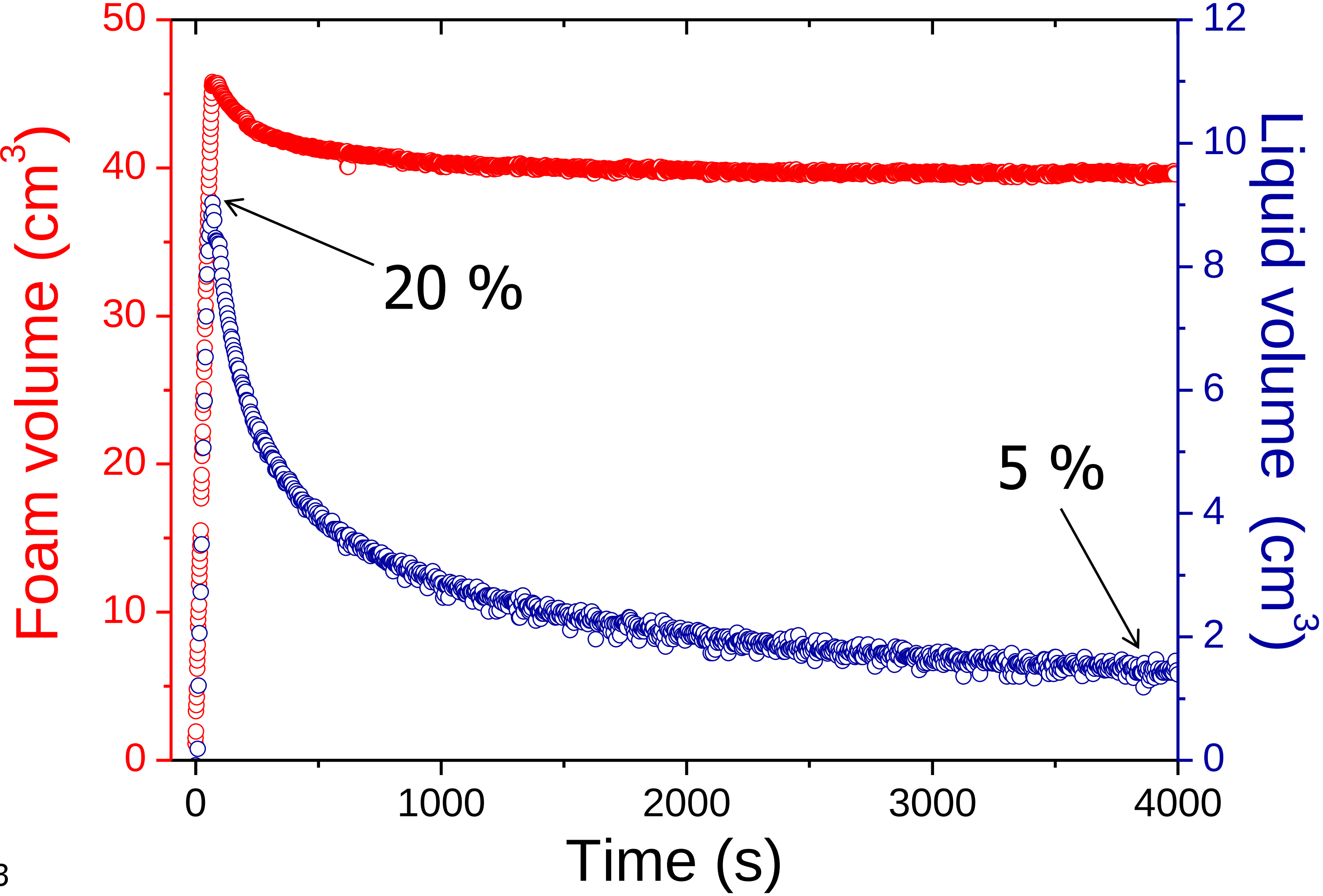



Concentration: 10 g/L
Flow rate =35 mL/cm$^3$

# Formation and foam stability at 25°C



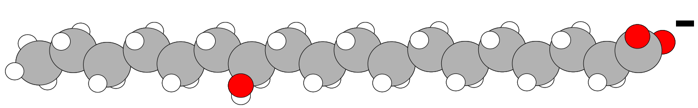


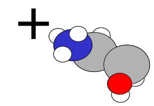

Concentration: 10 g/L
Flow rate =35 mL/cm$^3$

Optimal foamability and very stable foam !

# Formation and foam stability at 25°C

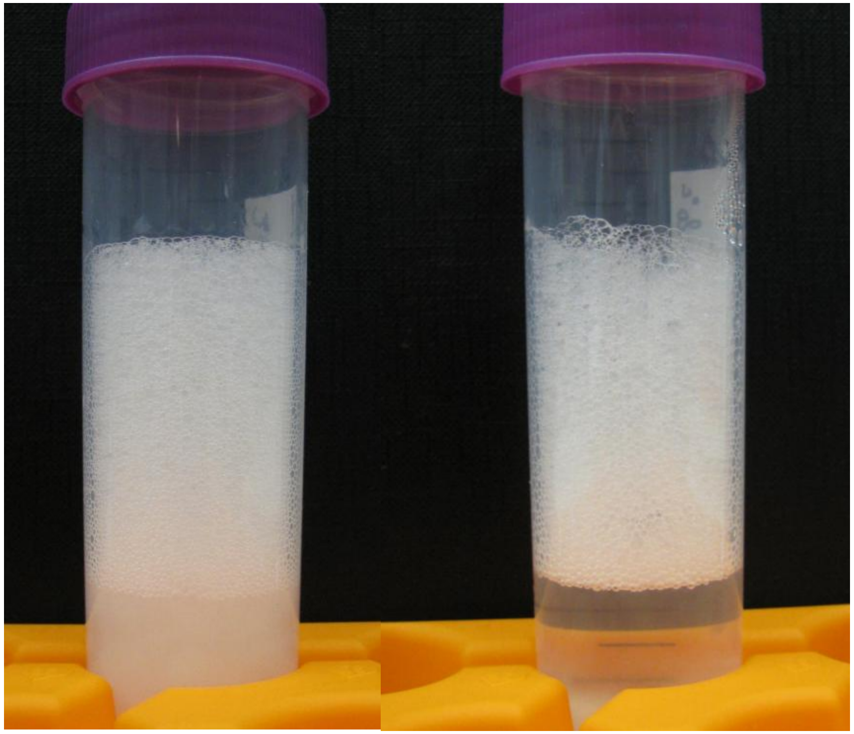


12 hydroxystearic acid



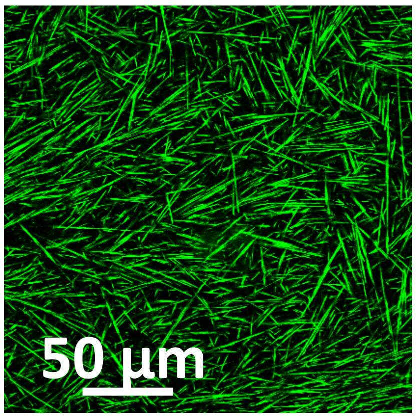
2 amino 1 ethanol

t=0 t=6 months

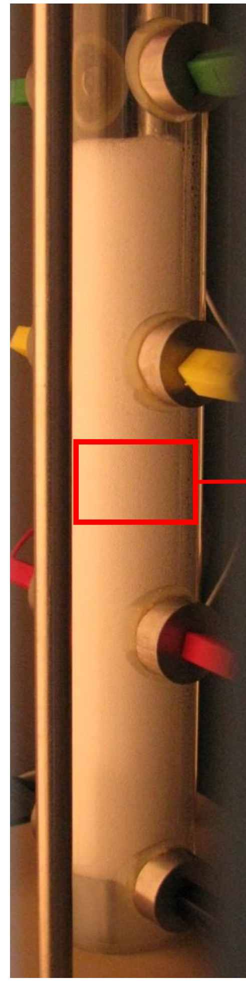


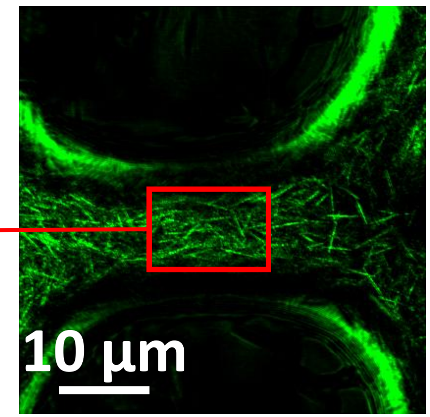
Ultrastable foam!

# Structure of the foam at 25°C




bulk

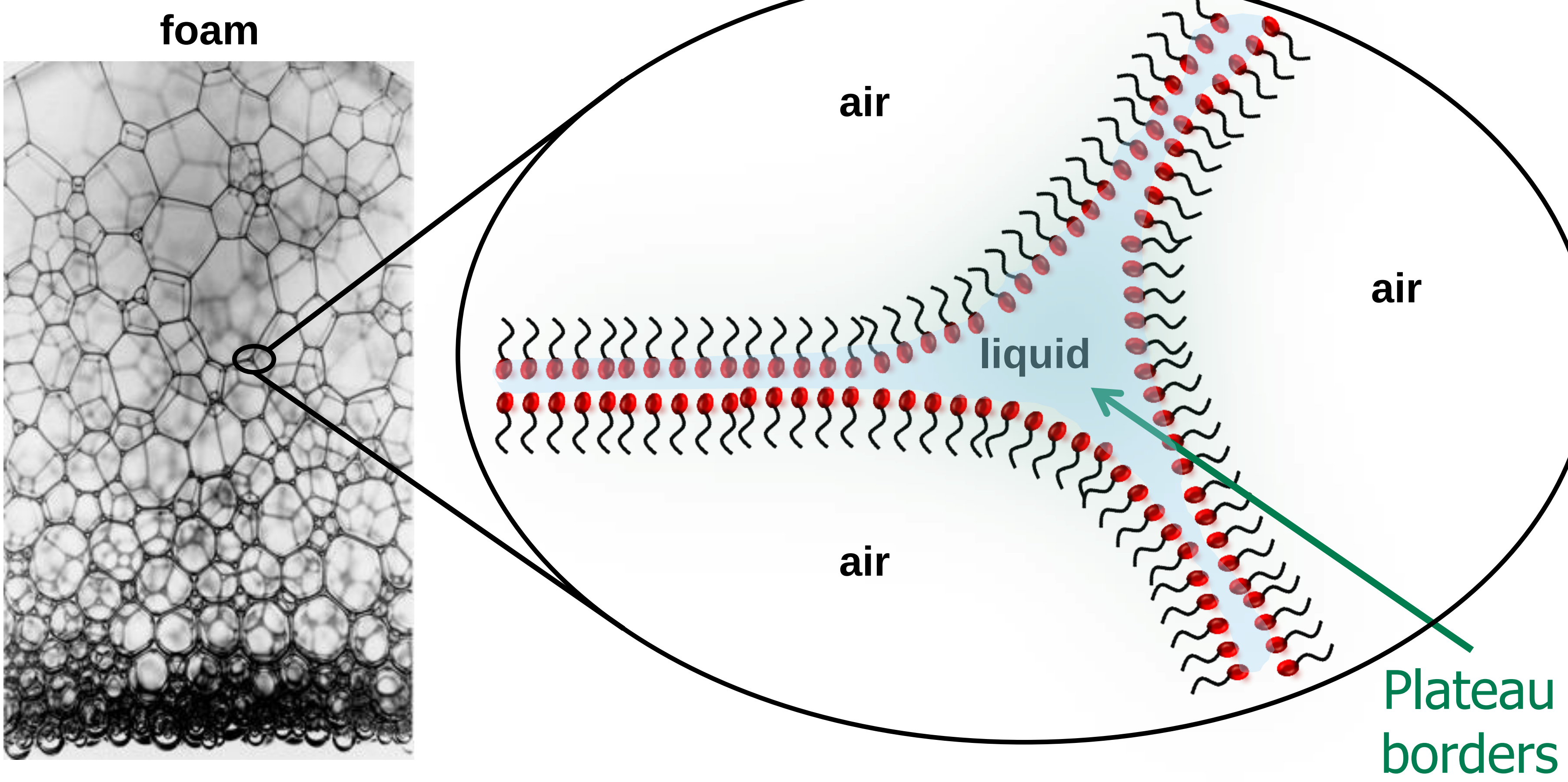




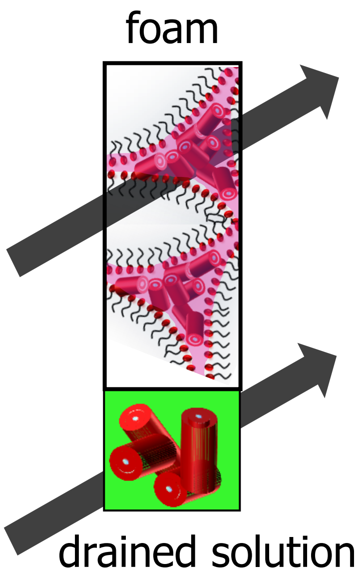

foam

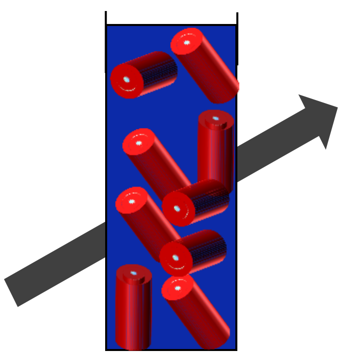
Tubes are present in the foam

# Foam structure: Plateau borders

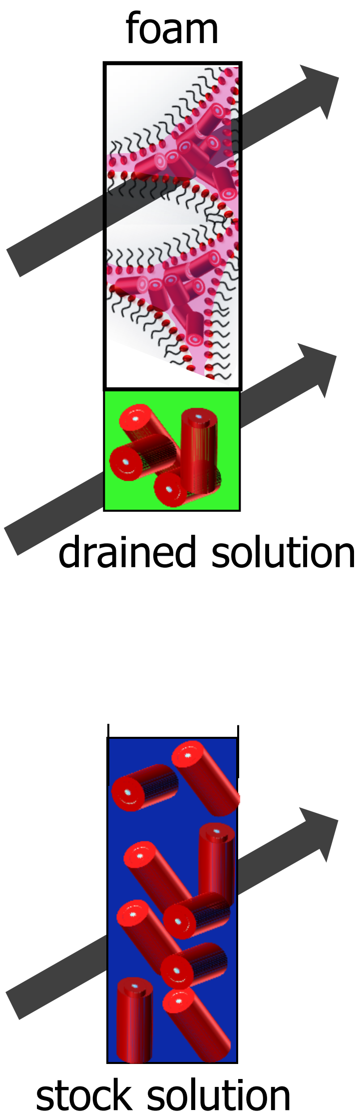


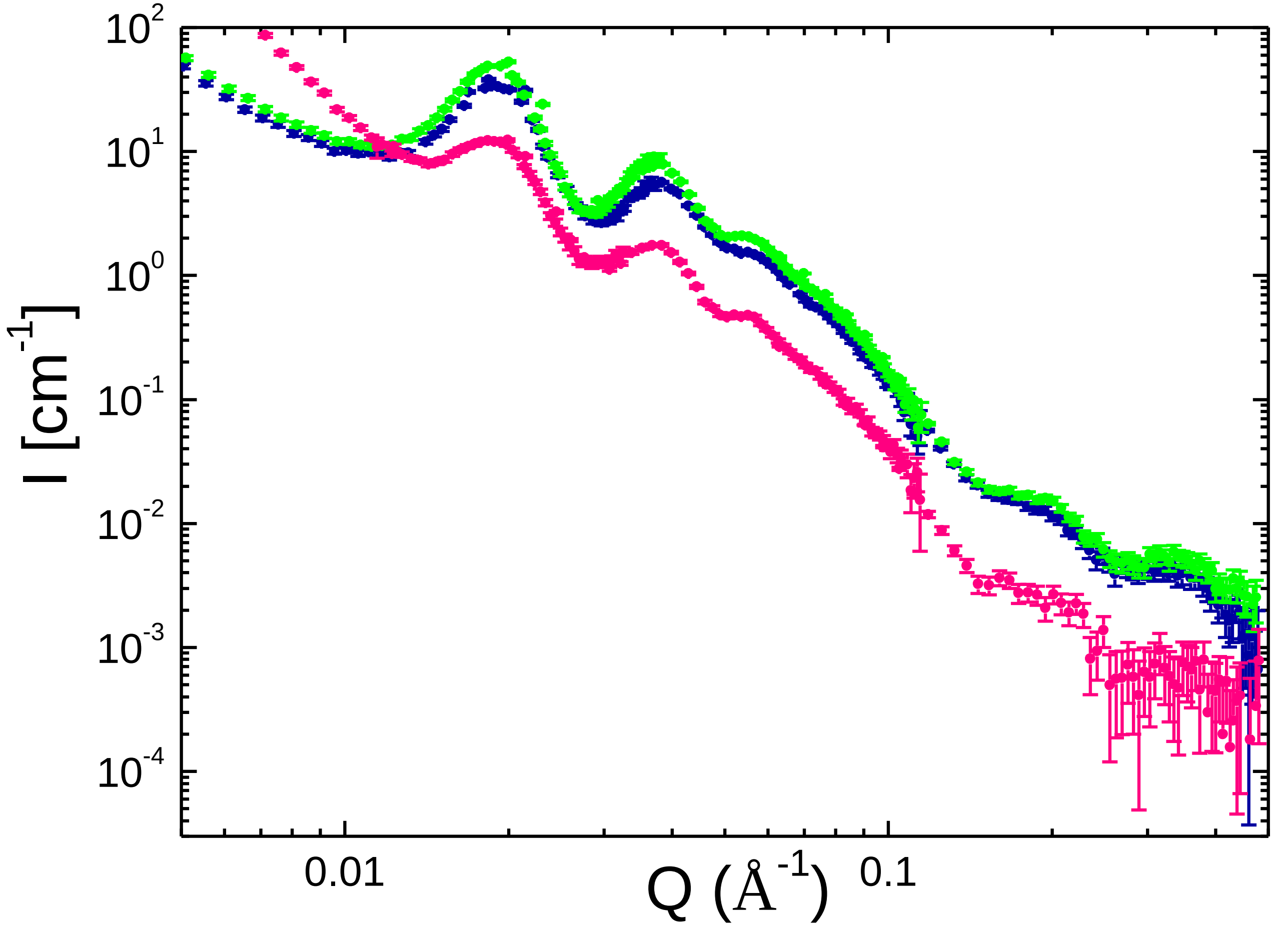
# Tubes structure in the Plateau borders



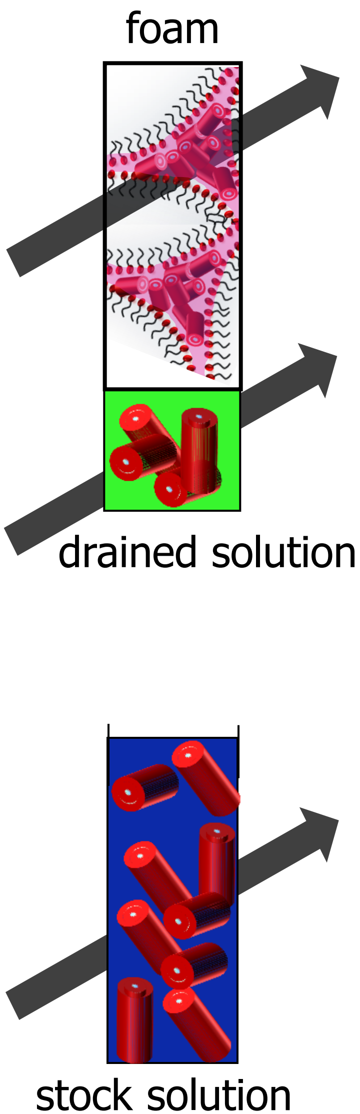



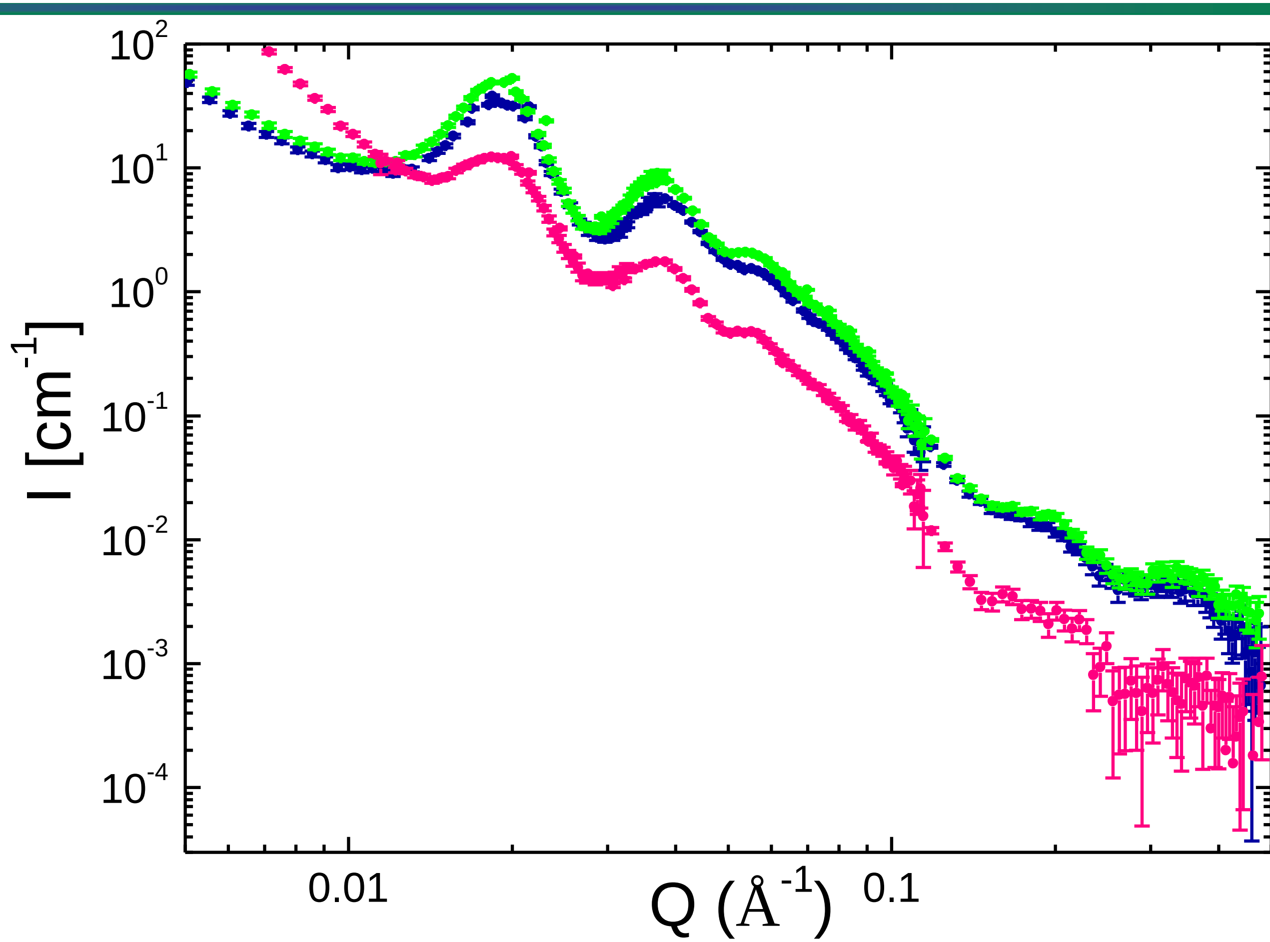
# Tubes structure in the Plateau borders



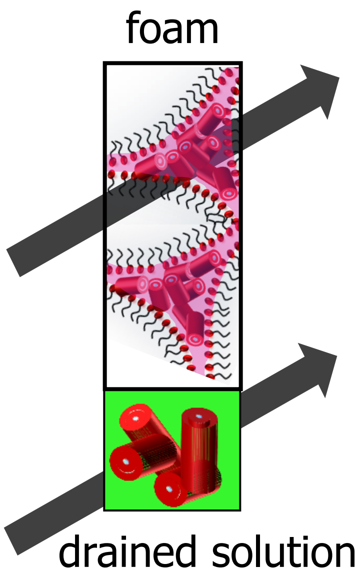
# Tubes structure in the Plateau borders

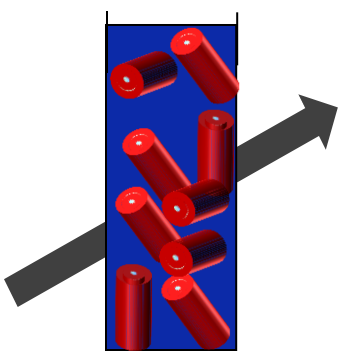


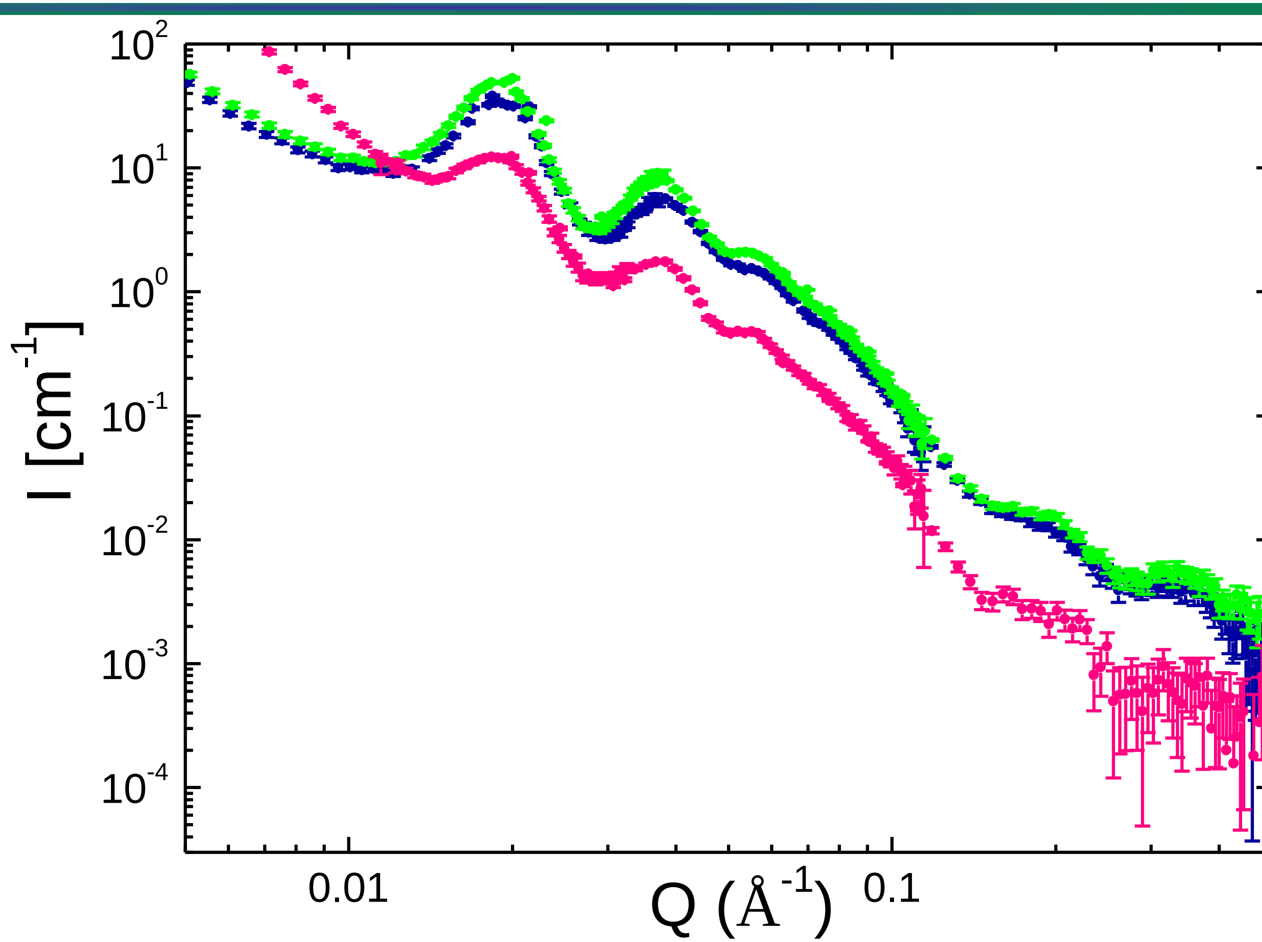




Same structure of tubes in bulk and in the foam.

# Tubes structure in the Plateau borders



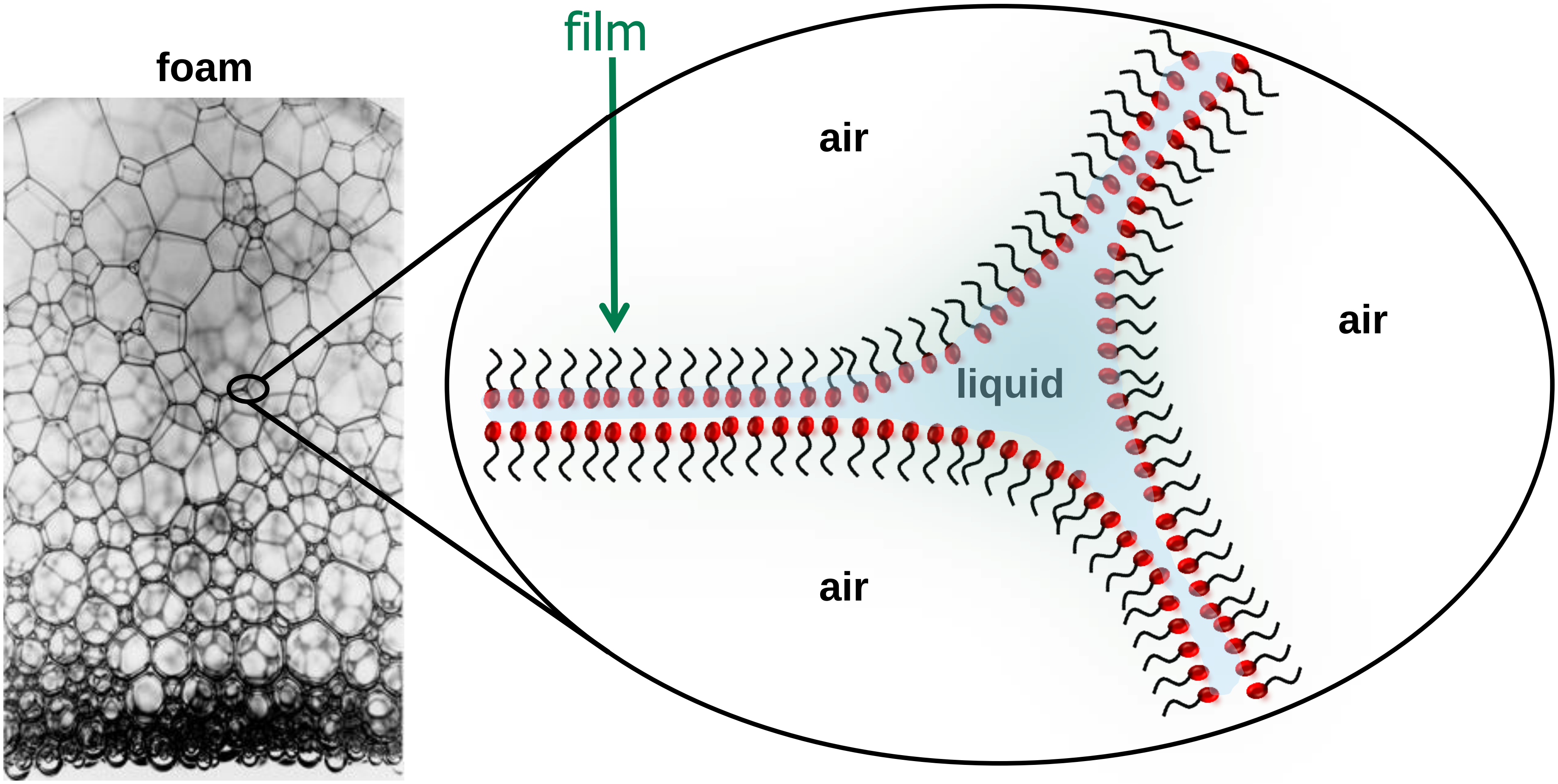



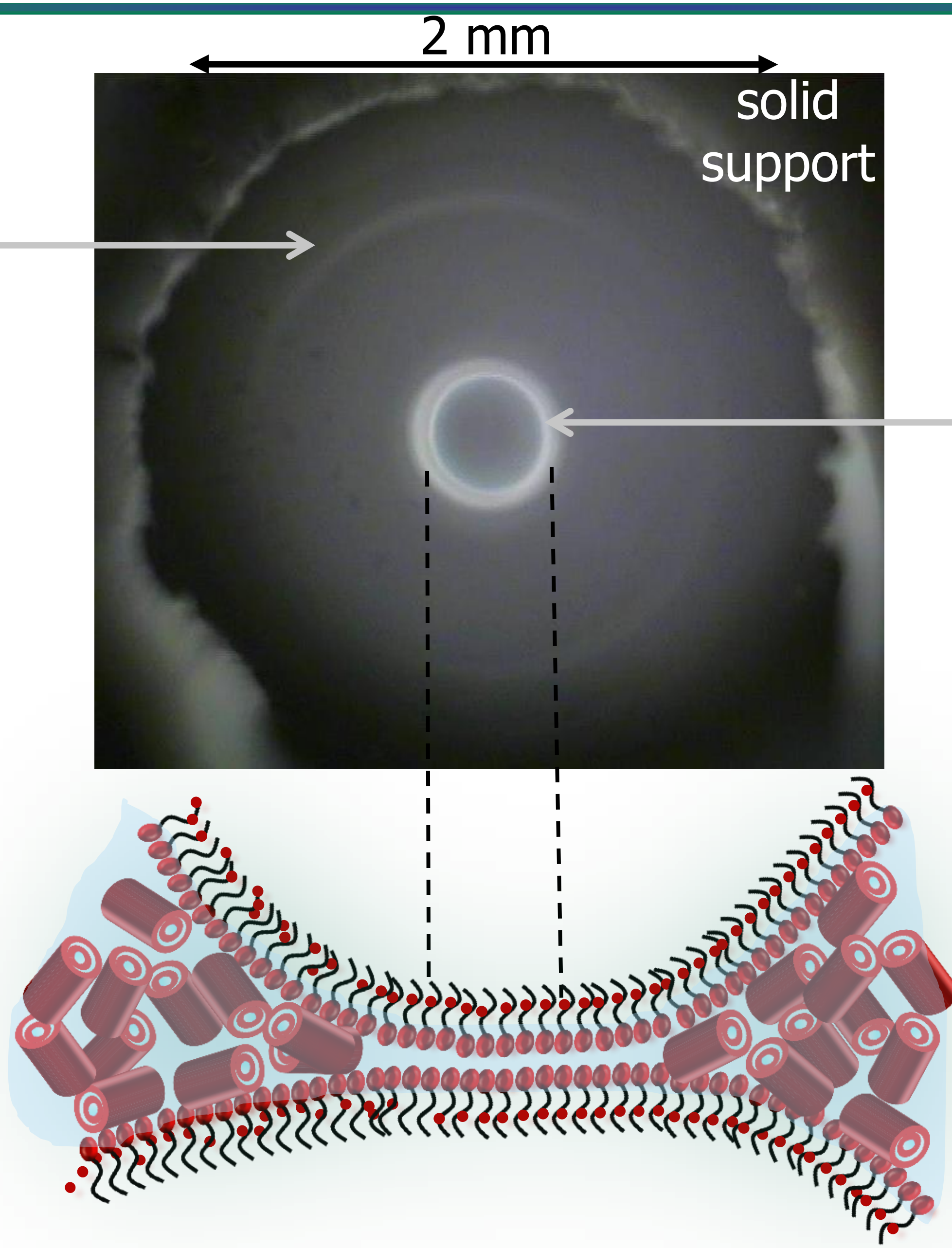

Same structure of tubes in bulk and in the foam.

→ Drainage reduction!

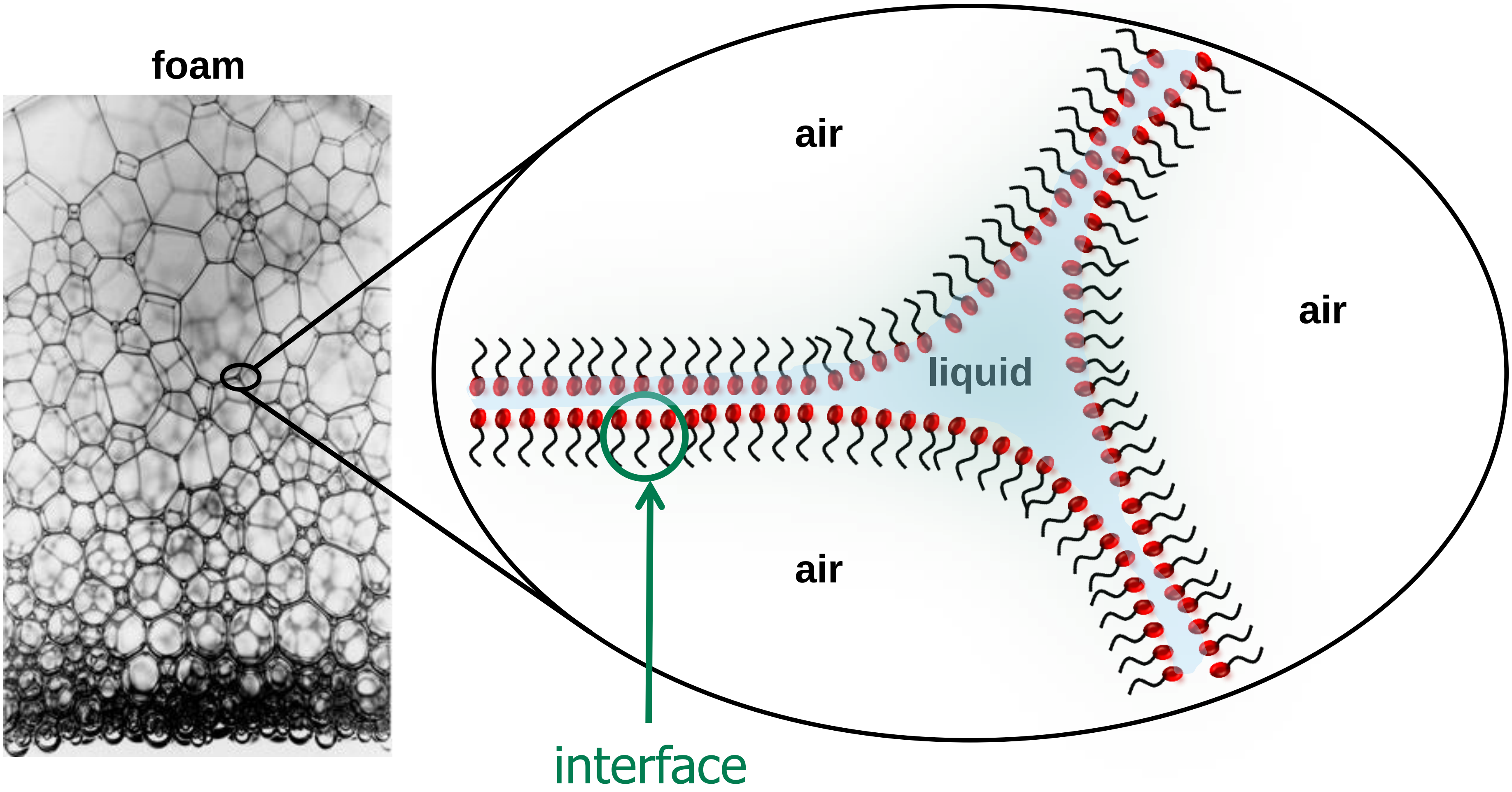
# Foam structure: interfacial film



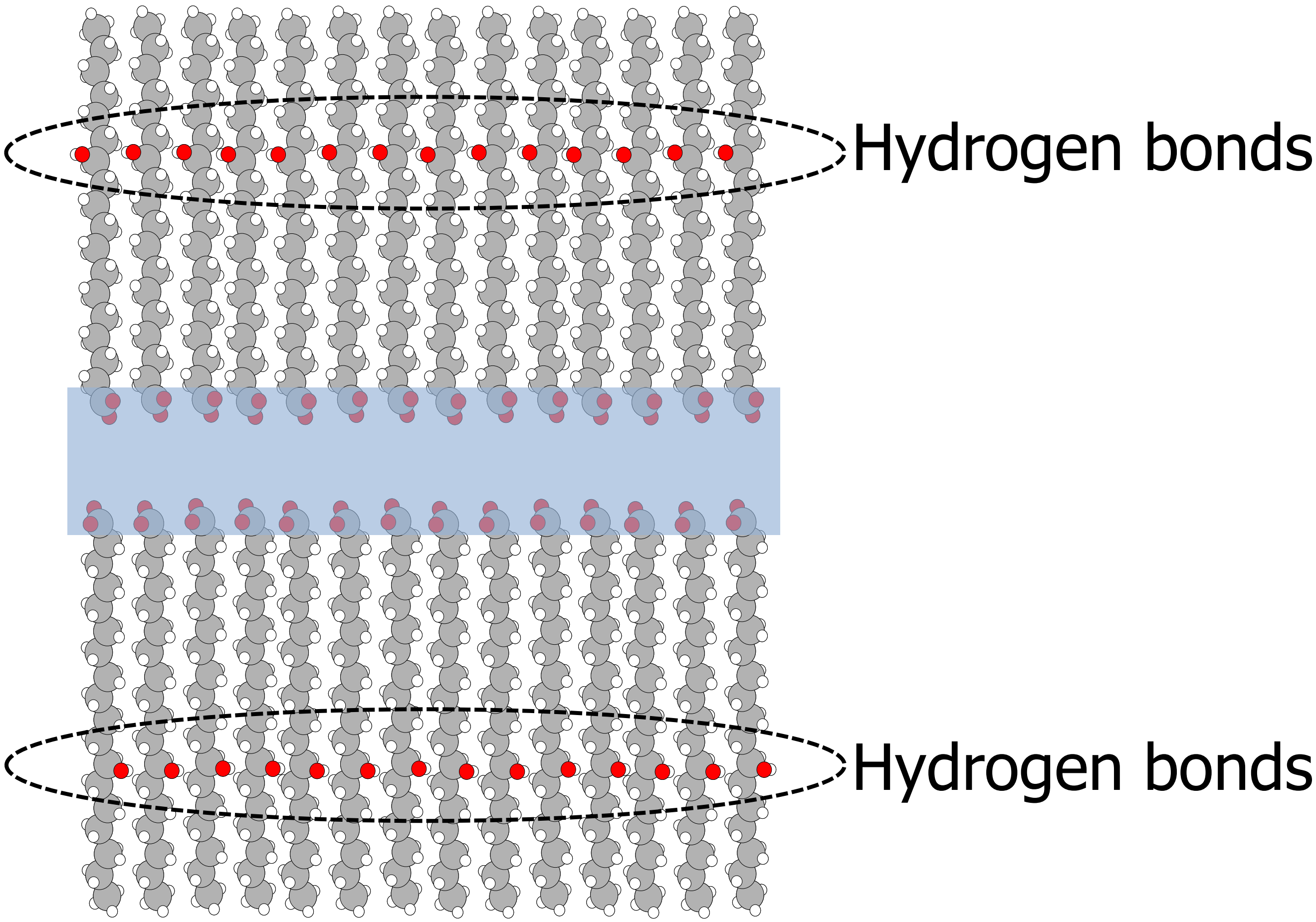
# Foam structure: interfacial film



# Foam structure: air/water interface



# Foam structure: air/water interface

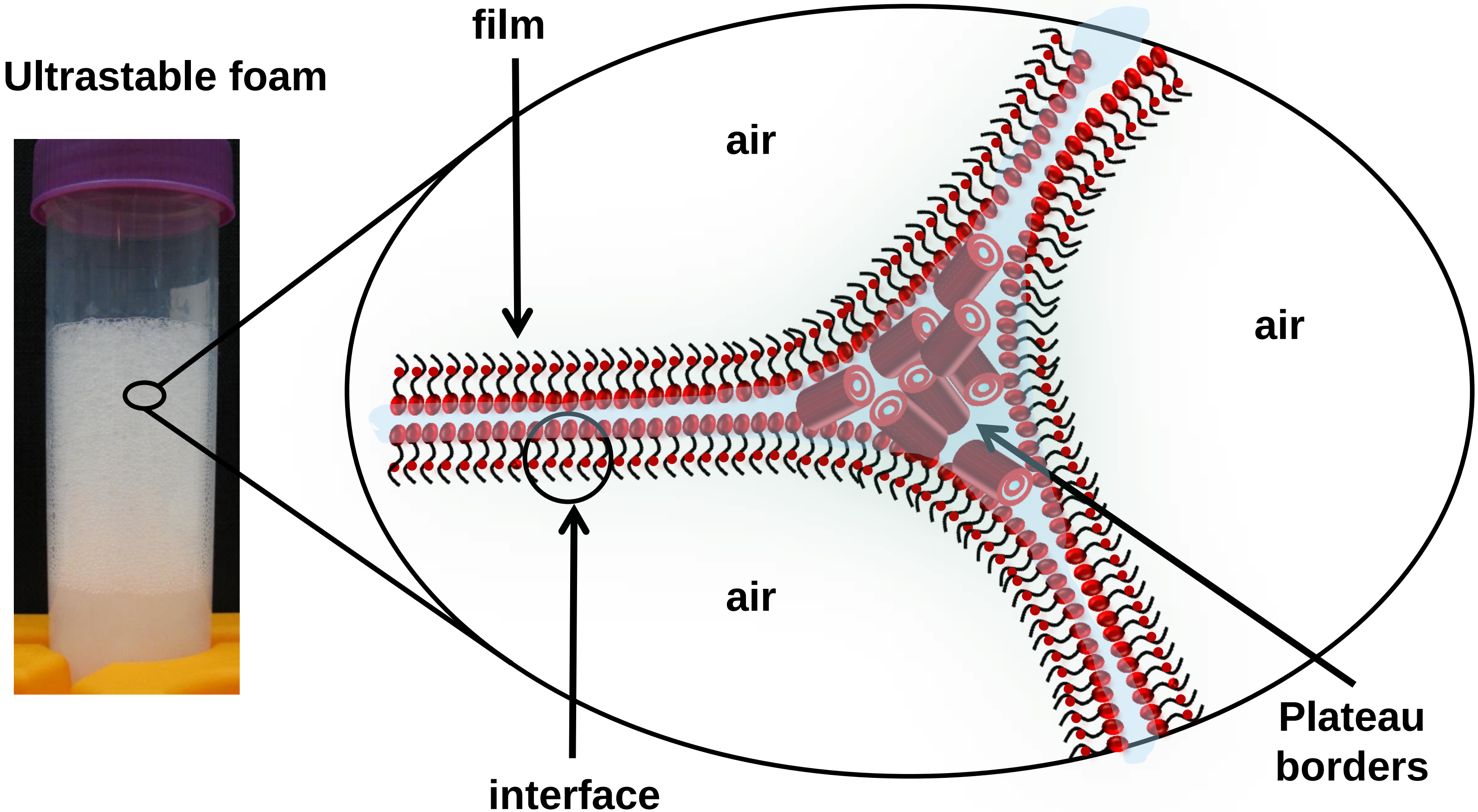



Dense monolayer and very elastic

Coarsening and coalescence are blocked

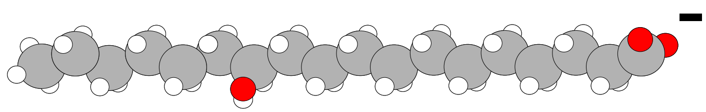
Yim K.S.,Rahaï B., & Fuller G.G., (2002) Langmuir, 17, 6597-6601.

# Overview: foam structure at 25°C

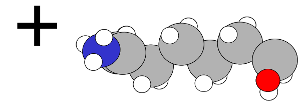



Drainage reduction, coalescence and coarsening are blocked!

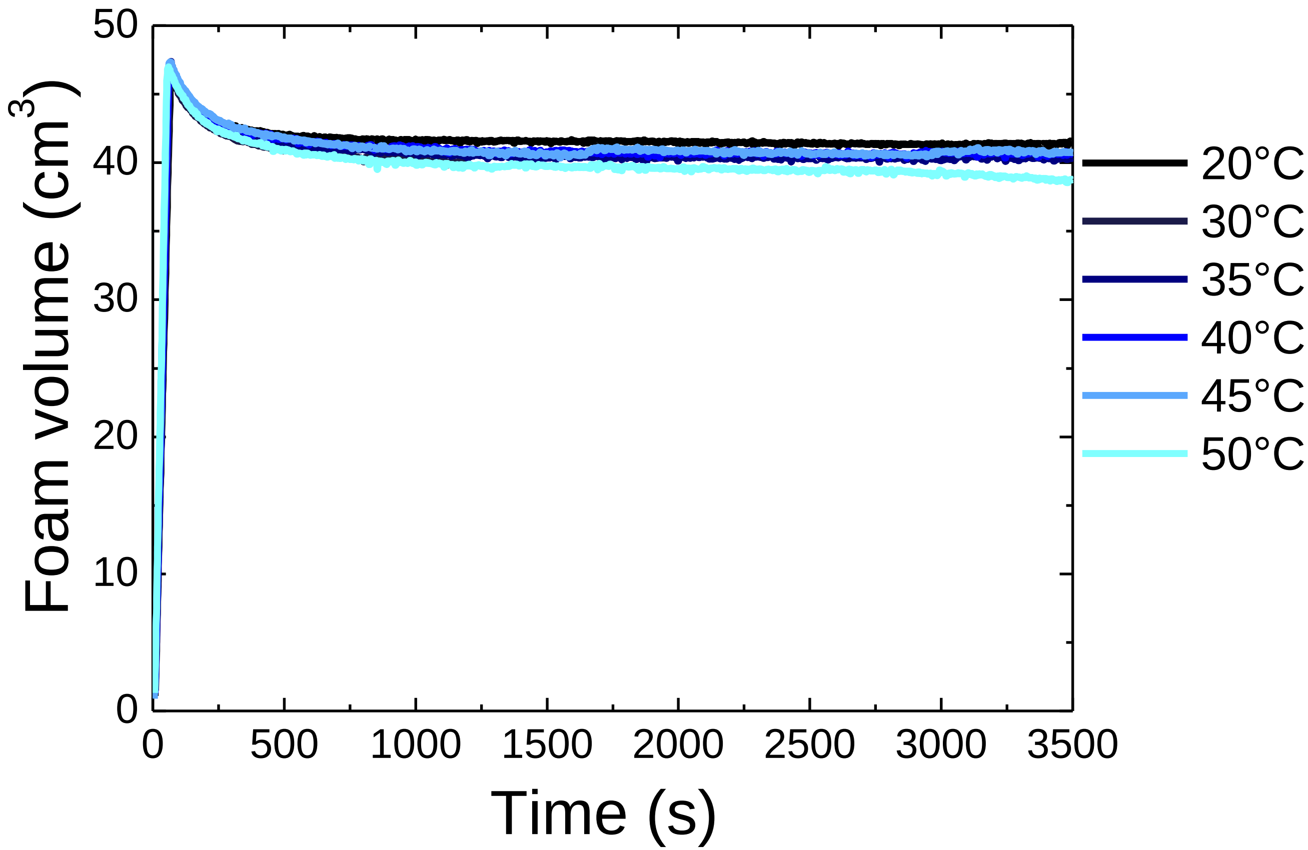
# Evolution with the temperature

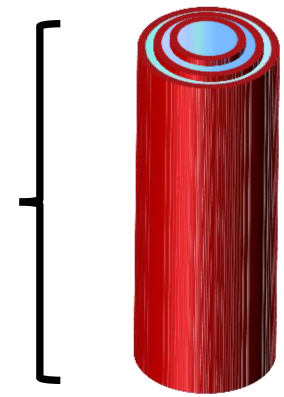


12 hydroxystearic acid

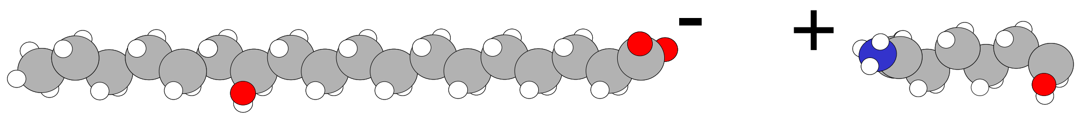


6 amino 1 hexanol



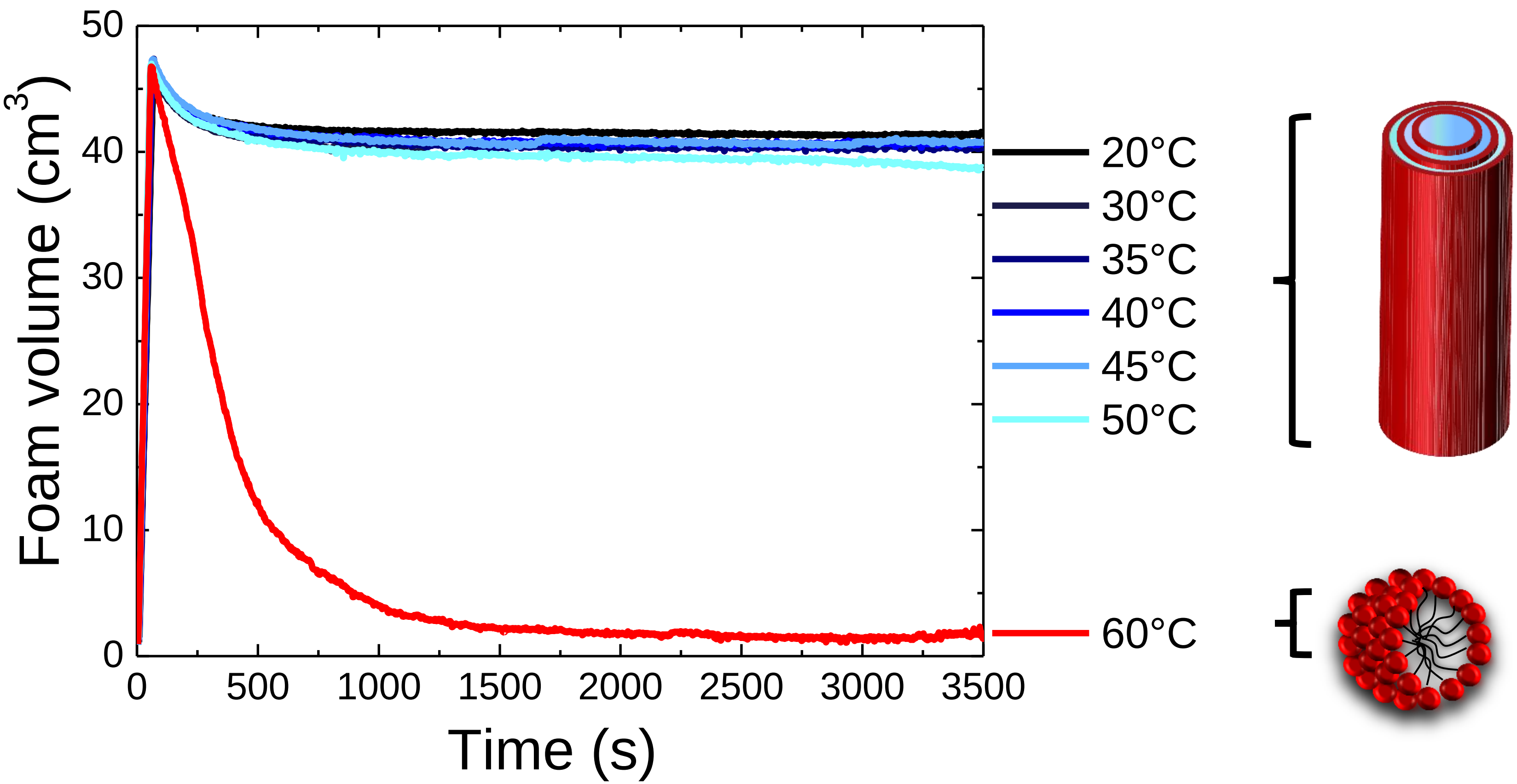



# Evolution with the temperature



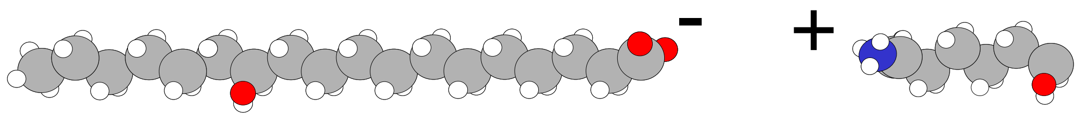

12 hydroxystearic acid

6 amino 1 hexanol

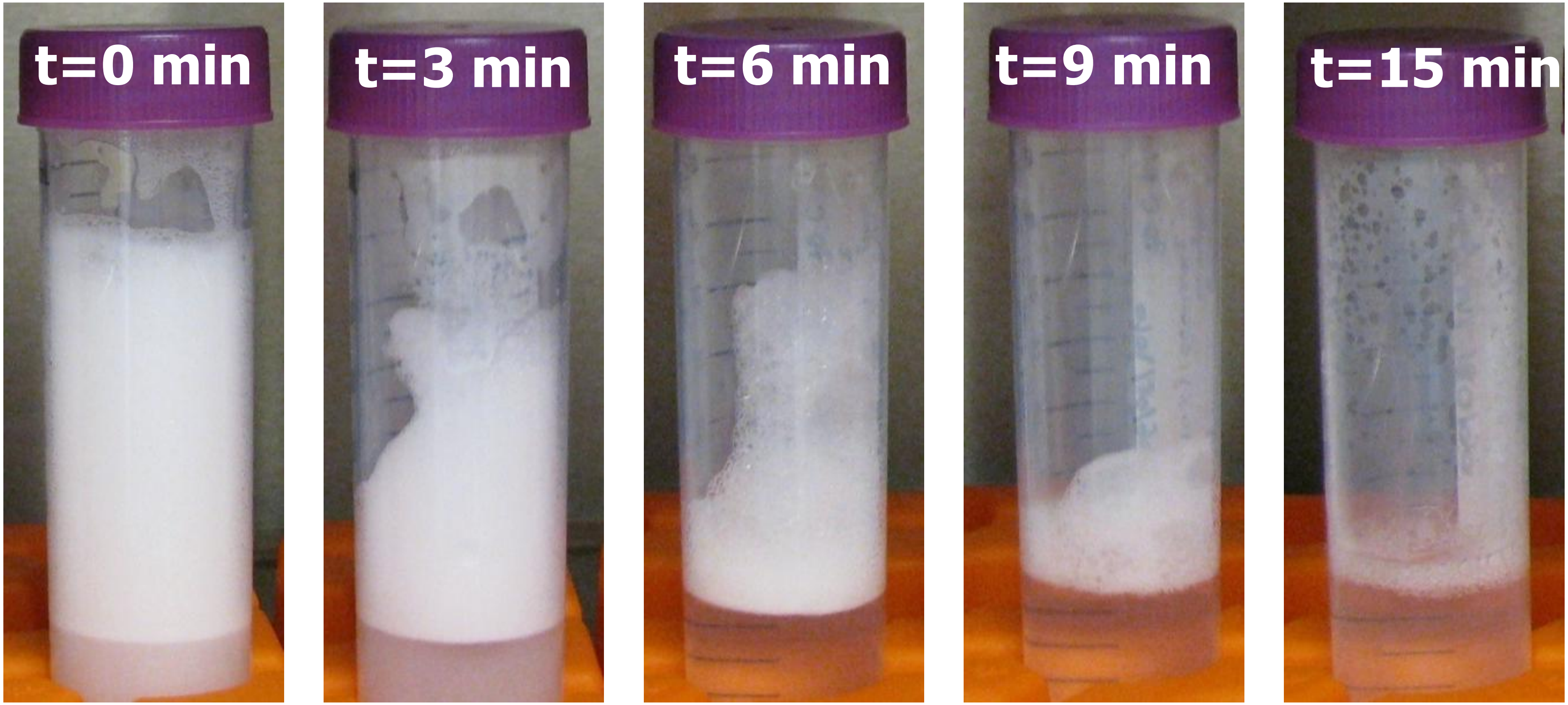



Tubes are responsible for the foam stability.

# Evolution at 60°C

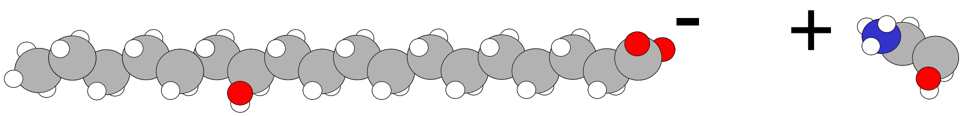



12 hydroxystearic acid 6 amino 1 hexanol

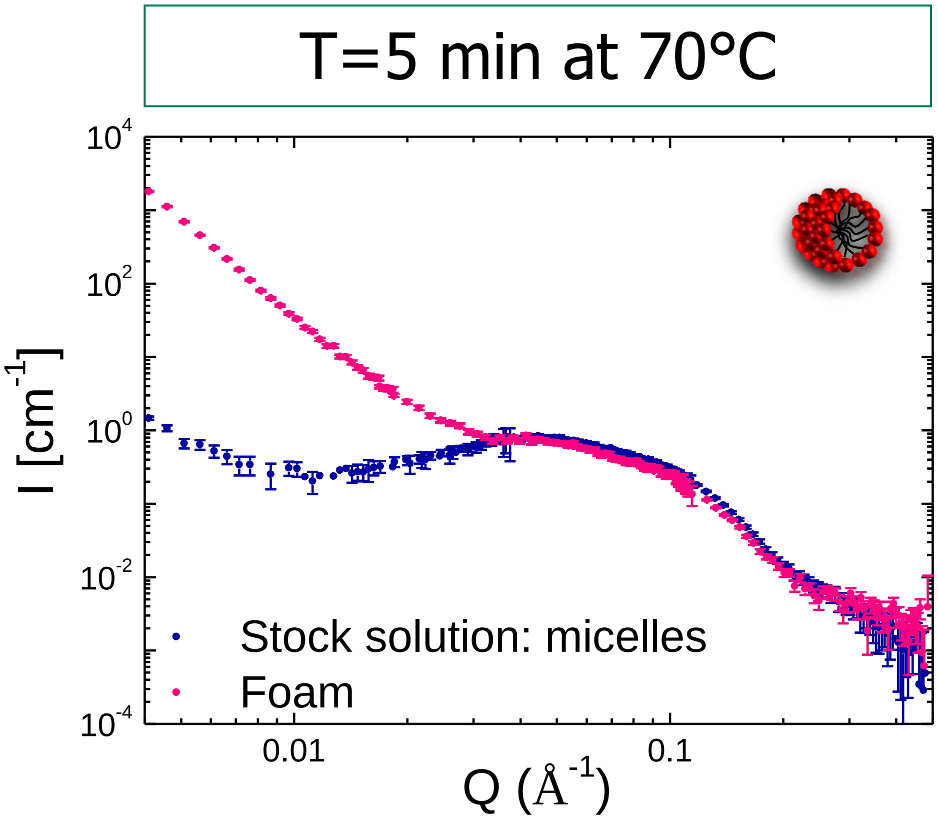


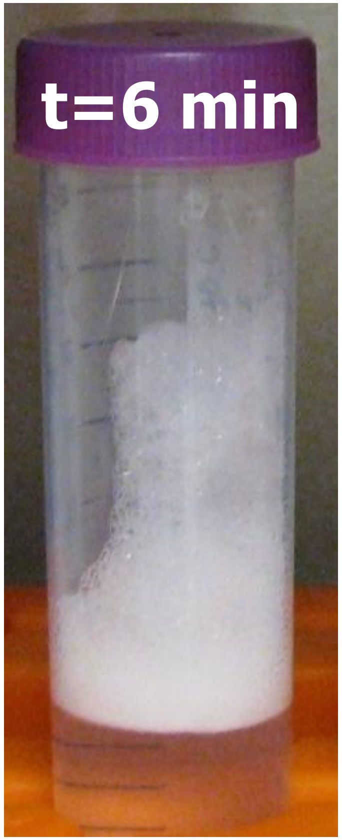

Very fast destabilisation!

# Foam structure at 70°C: Plateau borders




12 hydroxystearic acid 2 amino 1 ethanol

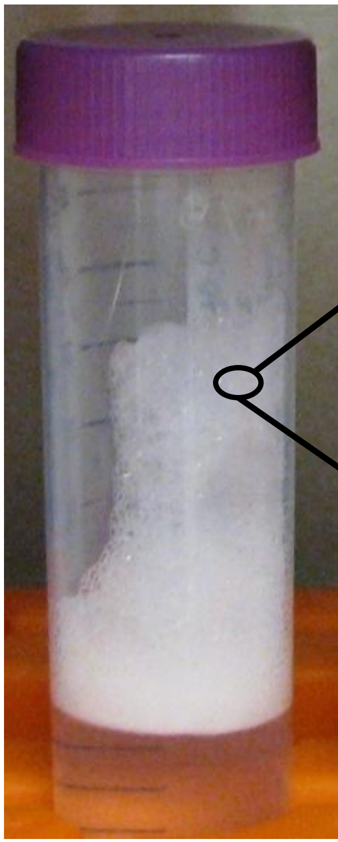


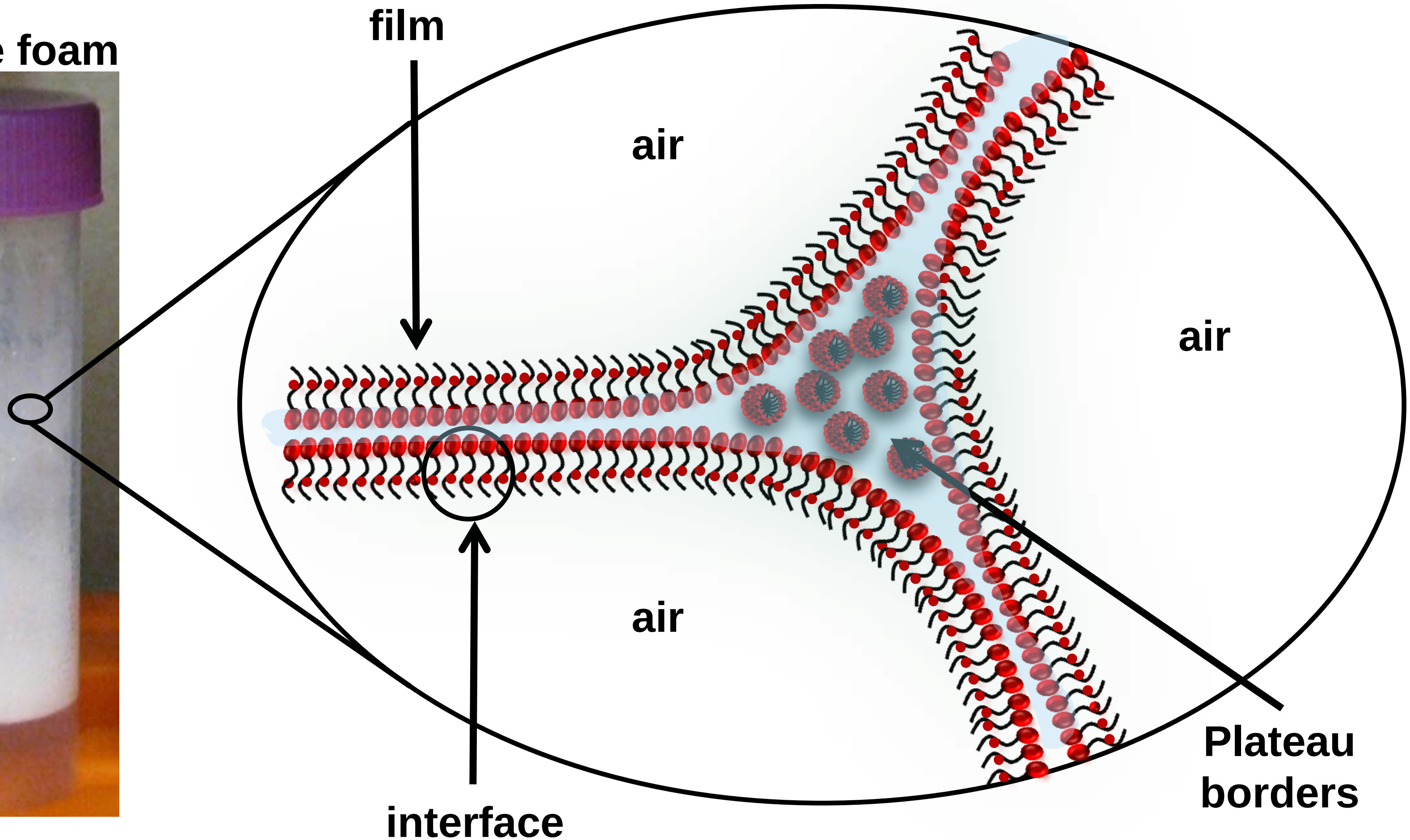




Tubes melt into micelles *in situ* in the foam

# Overview: T>Tfusion

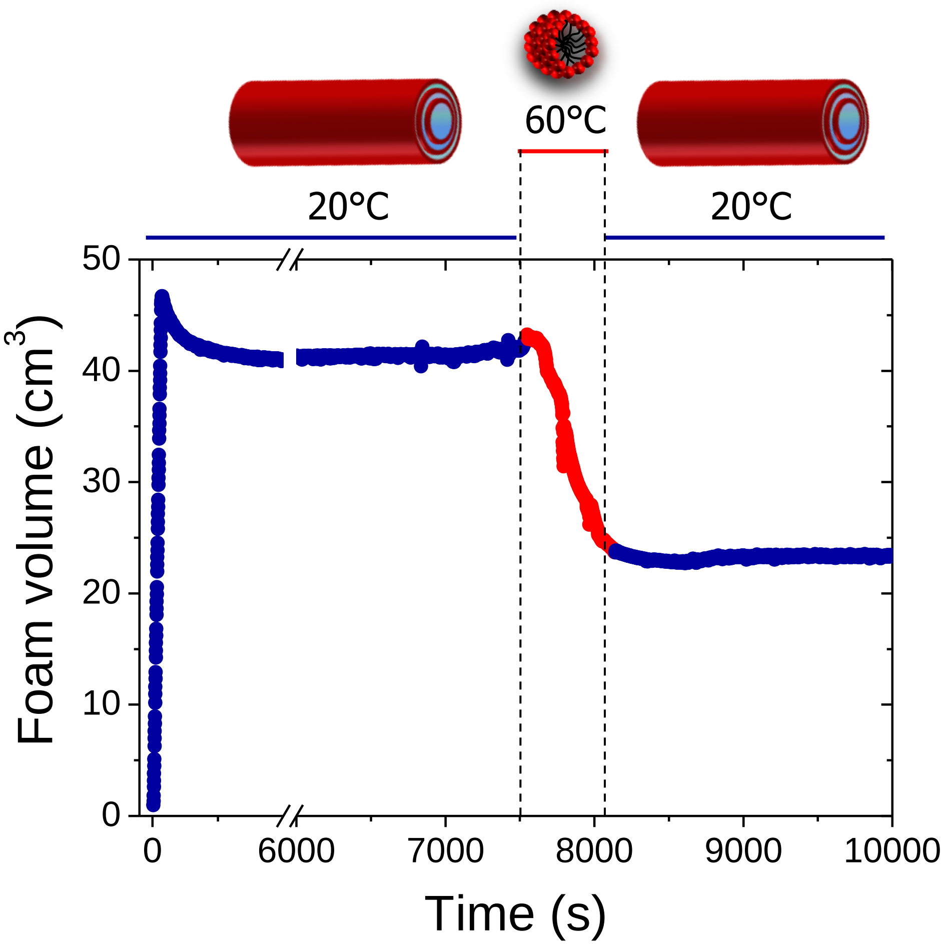
Unstable foam






Very fast destabilisation because of the tubes/micelles transition!

# Evolution during temperature cycles

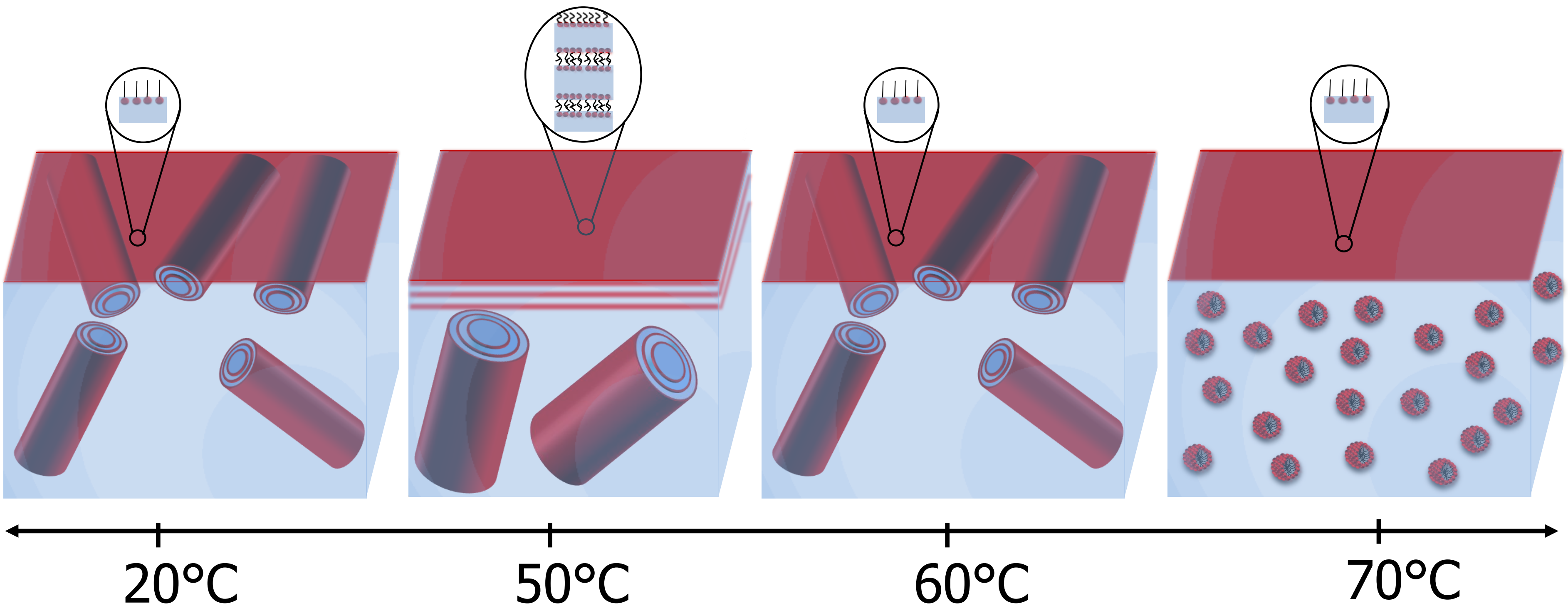



Temperature tuneable foams!

Fameau A.L., *et al*. (2011), Angewandte Chemie International Edition,50, 8264-8269.

# Conclusions

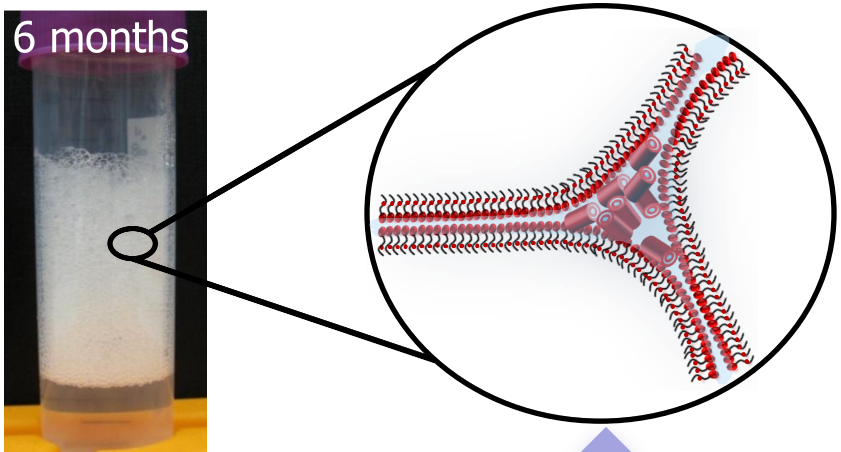
# Conclusions : structure of tubes at the interface?




Structural transitions at the interface are reversible!

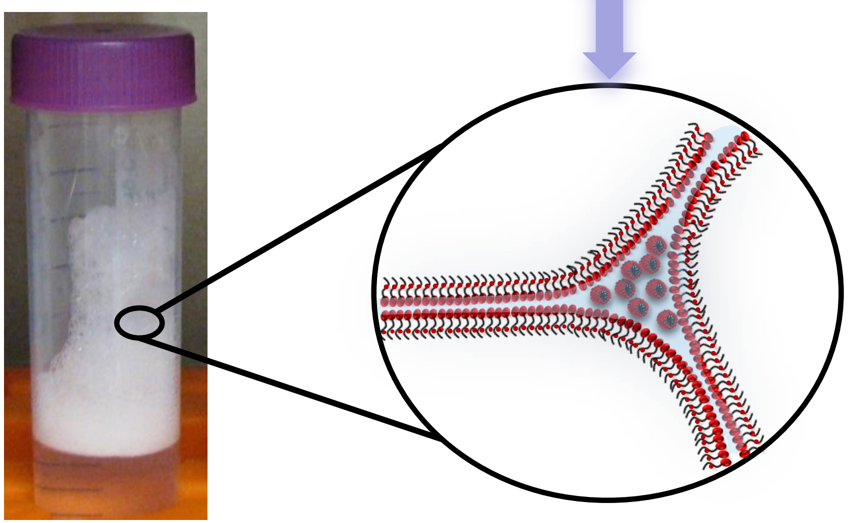
→ Interface easily temperature tuneable!

# Conclusions : Foaming properties of tubes?




Optimal foamability

Ultrastable foams



Very fast foam destabilization!

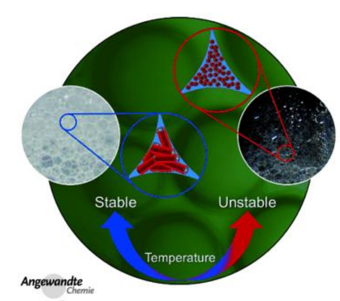
Communications

Foams

DOI: 10.1002/anie.201102115

**Smart Foams: Switching Reversibly between Ultrastable and Unstable Foams****

*Anne-Laure Fameau, Arnaud Saint-Jalmes, Fabrice Cousin, Bérénice Houinsou Houssou, Bruno Novales, Laurence Navailles, Frédéric Nallet, Cédric Gaillard, François Boué, and Jean-Paul Douliez**




Temperature tuneable foams!

# Acknowledgment


- Jean-Paul Douliez & Bruno Novales
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- Bérénice Houinsou Houssou & Cédric Gaillard
- Frédéric Nallet & Laurence Navailles
- Arnaud Saint Jalmes & Janine Emile
- Dominique Langevin, Wiebke Drenckhan, Emmanuelle Rio & Anniina Salonen