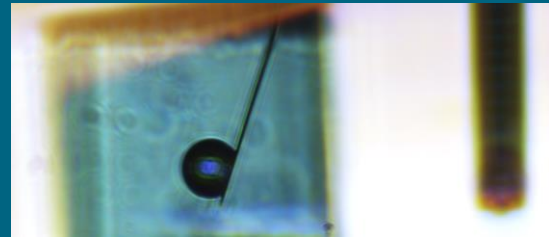


FluidFM to access the interactions between gaz/liquid and biological interfaces

I. Demir, I. Lüchtfeld, C. Lemen, P. Guiraud, E. Dague, T. Zambelli and C. Formosa-Dague



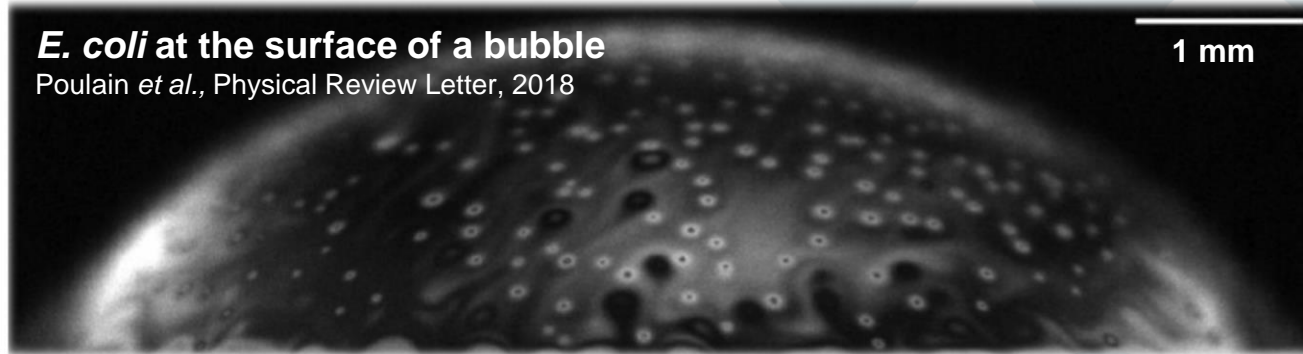
@CecileFormosa



Toulouse Biotechnology Institute
Bio & Chemical Engineering

Understand and control the interactions bubbles-microorganisms

Challenges: ubiquitous interactions, essential for microorganisms, involved in many processes, for example in the field of process engineering or biotechnology



Understand and modulate these interactions to control the processes in which they are involved

New tools to measure the interactions with bubbles

Develop strategies to functionalize bubbles

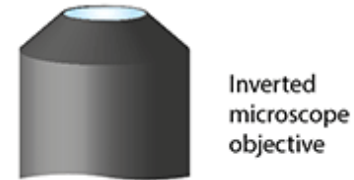
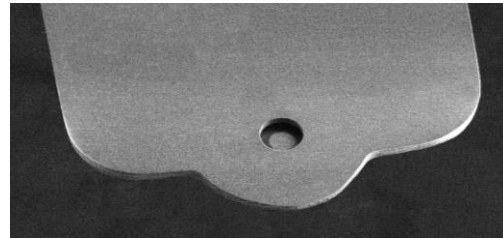
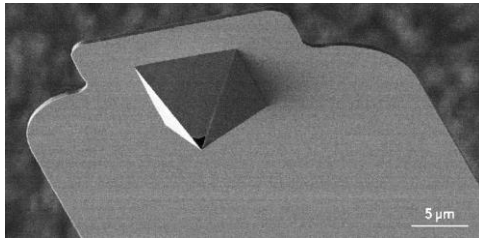
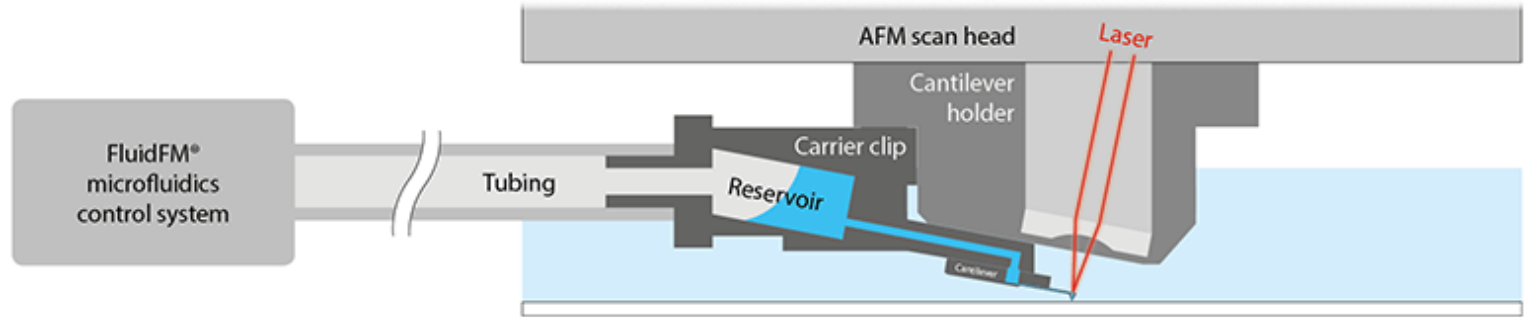
FluidFM technology

Technological challenges:

- Produce stable microbubbles (gas dissolution)
- Functionalize bubbles with surfactants
- Measure their interactions with living microorganisms at the molecular level



FluidFM technology

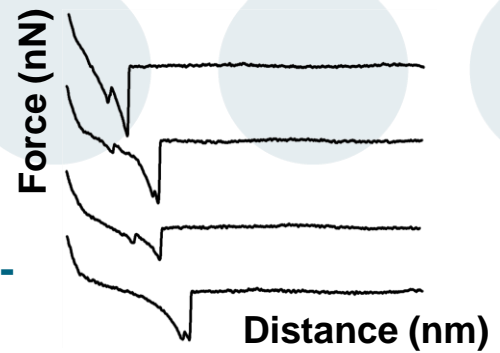
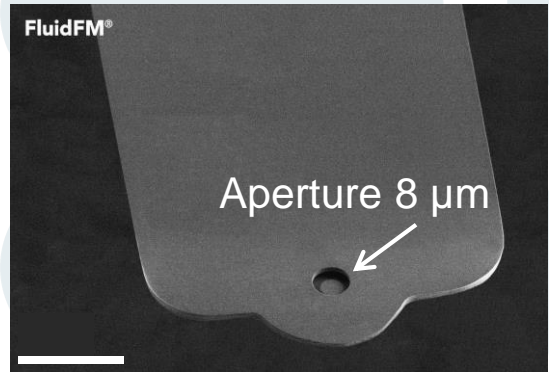
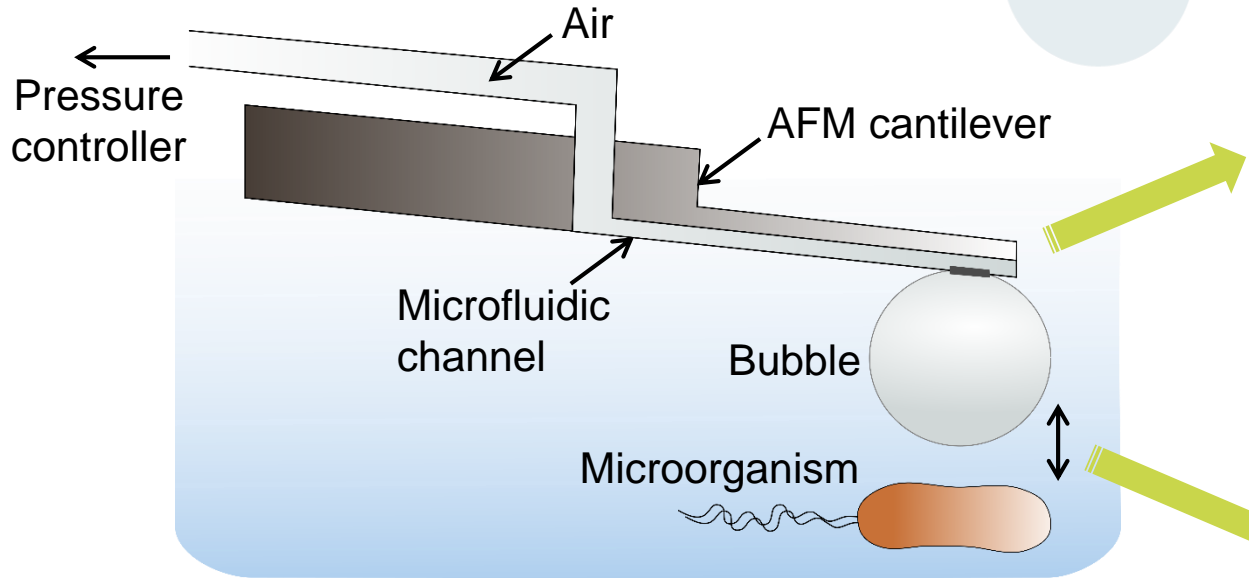


Meister *et al.*, NanoLetters 2009

Powerful tool used in various applications: cell adhesion, nano-injection of cells, lithography, patch-clamp, 3D printing...

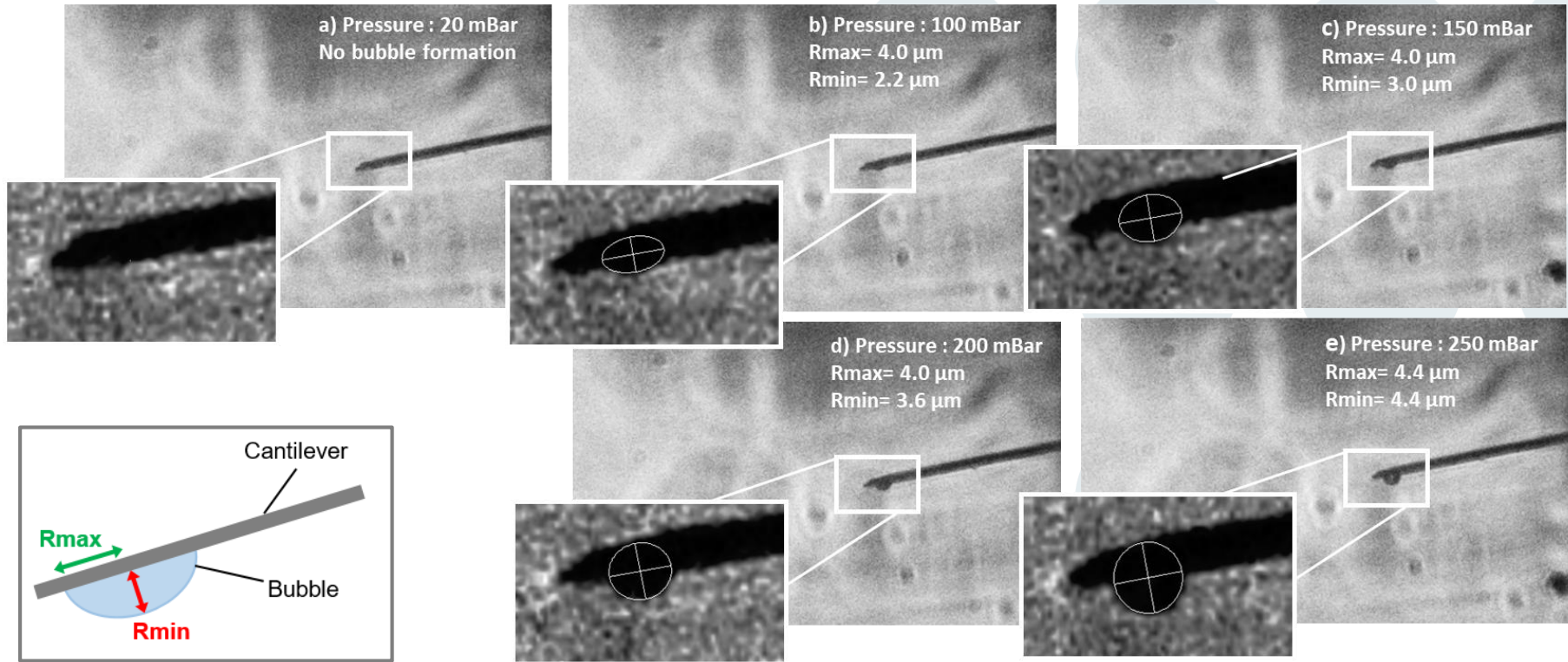
FluidFM to produce bubbles and measure interactions with cells

Using FluidFM in an original manner



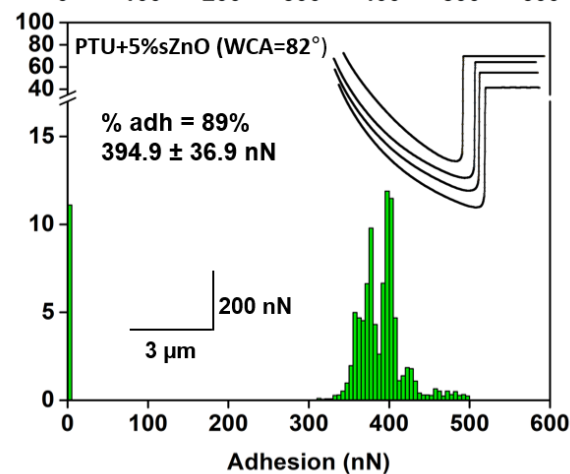
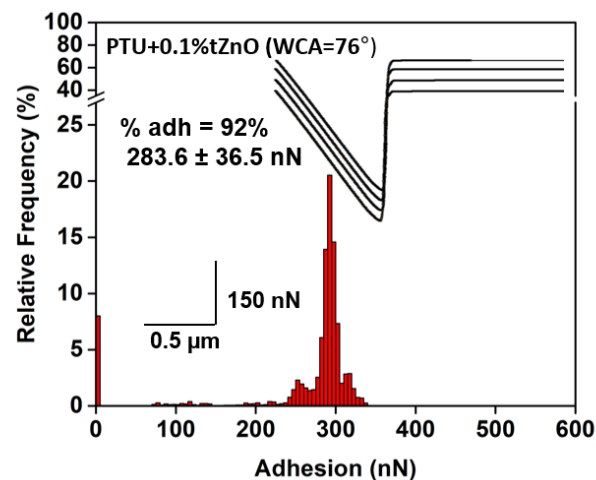
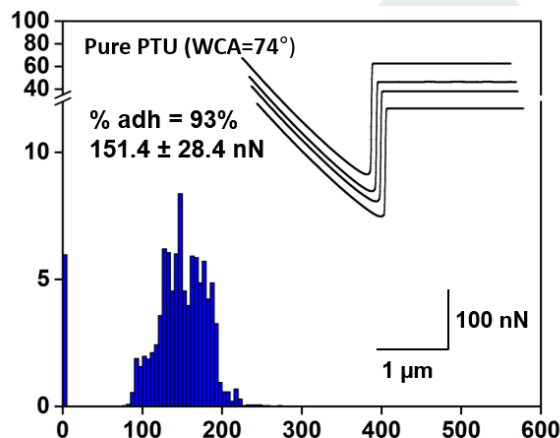
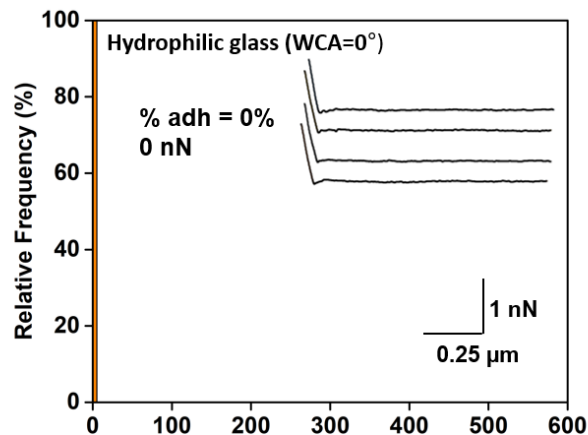
Biophysical measurement and characterization of bubble-microorganism interactions by AFM force spectroscopy

Fluid FM and bubbles: production of stable microbubbles



The size of the bubble depends on the pressure applied in the microfluidic channel

The bubble probe is a highly sensitive hydrophobic probe



Interactions with hydrophobic surfaces

Small differences in the water contact angles measured result in high adhesion force differences

⇒ FluidFM probe is a highly sensitive hydrophobic probe

The bubble probe is a sensitive hydrophobic + electrostatic probe

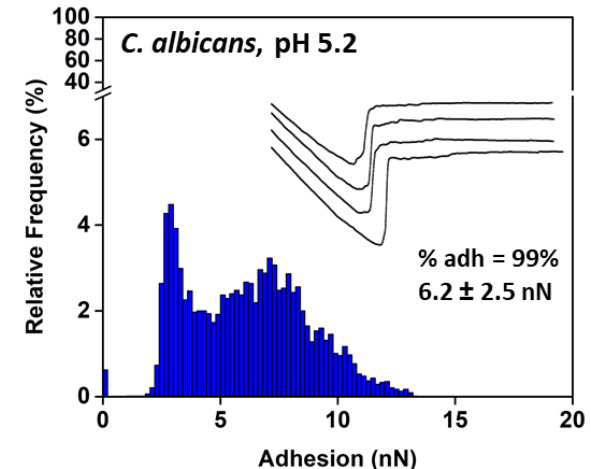
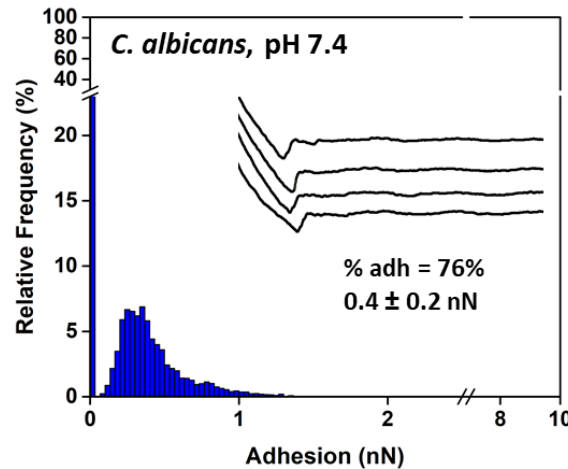
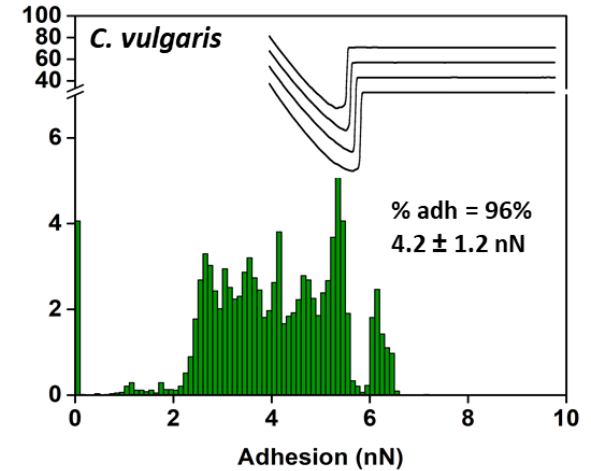
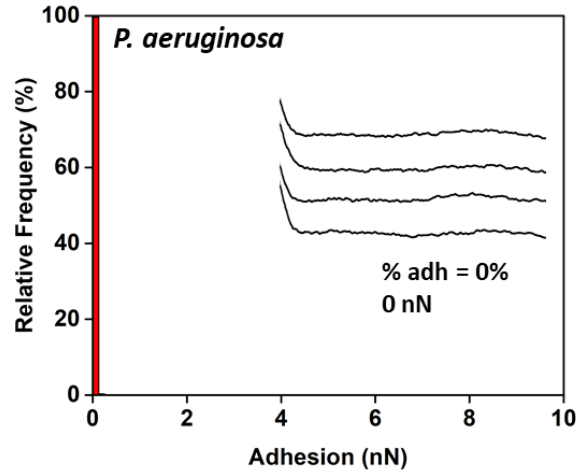
Interactions with microbes

Different microorganisms have different hydrophobic properties that we can measure with the bubble probe.

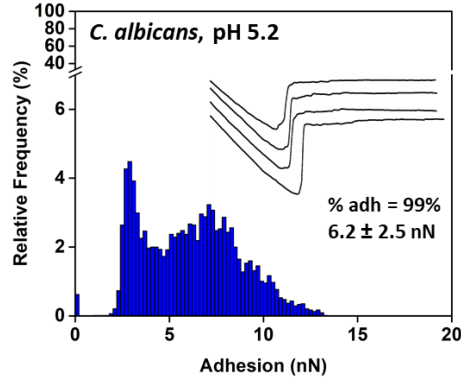
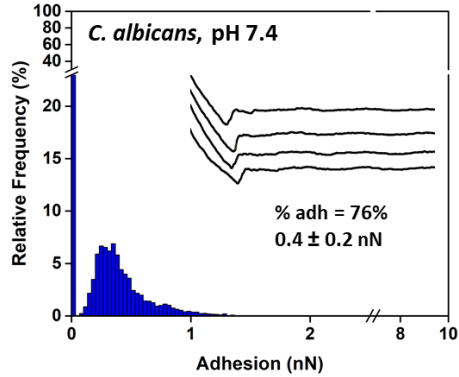
In the case of *C. albicans*, experiments performed at different pH give different adhesion values



Only hydrophobicity?



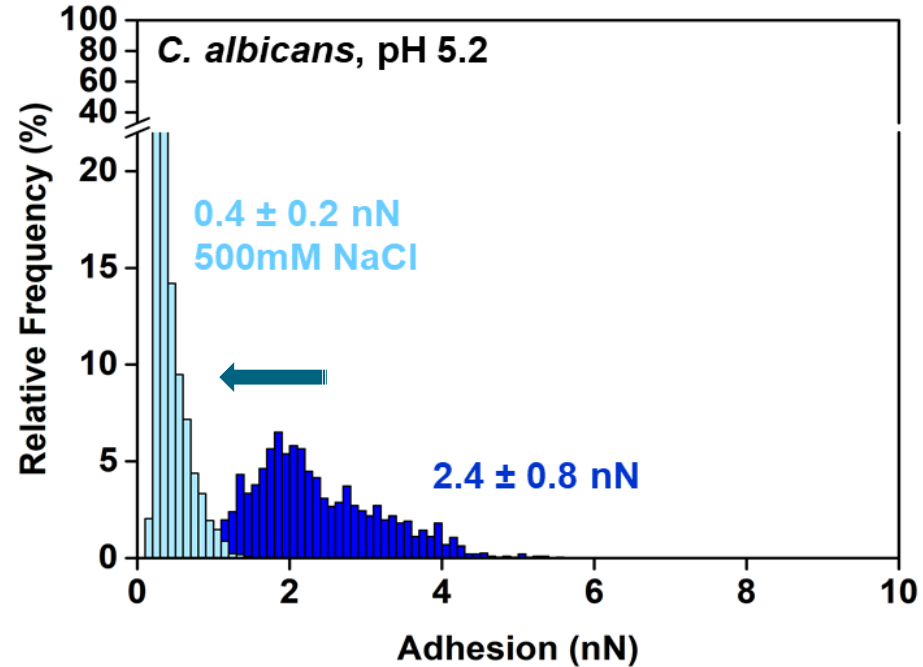
The bubble probe is a sensitive hydrophobic + electrostatic probe



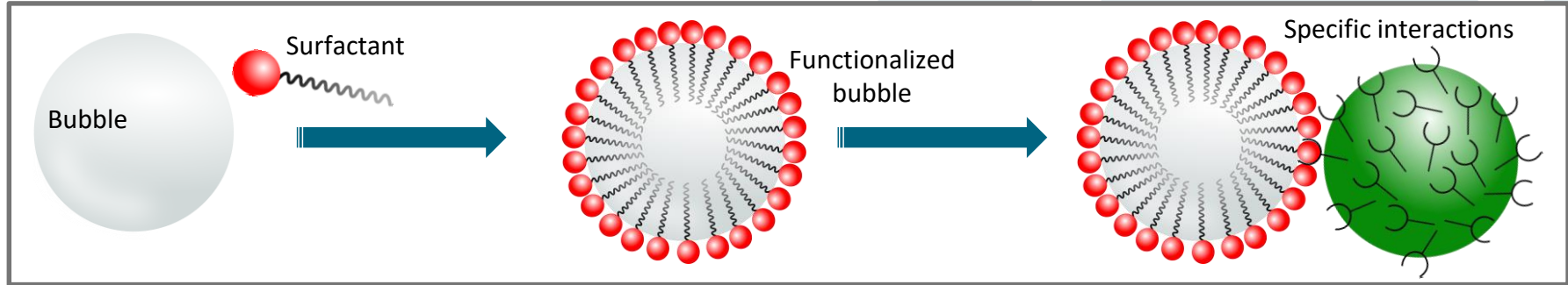
Case of *C. albicans*

Salts screen the charges on the cell and bubbles
⇒ decrease of the adhesion force recorded

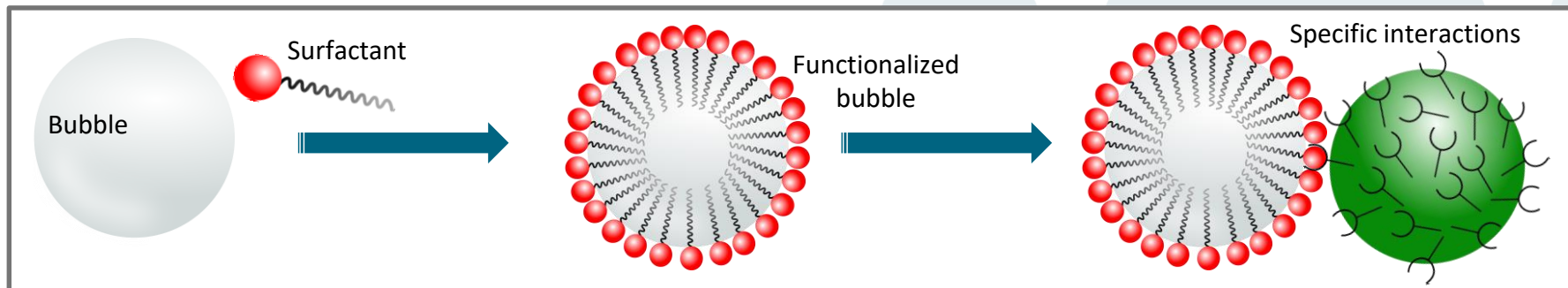
The bubble probe is also a
sensitive electrostatic probe



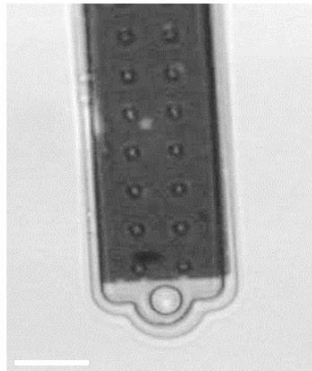
Modulate these interactions: bubble surface functionalization



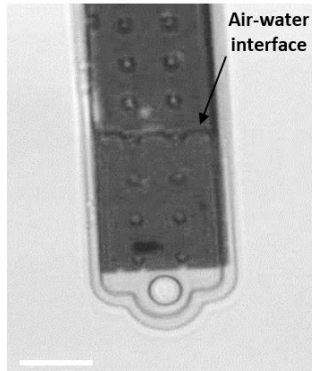
Modulate these interactions: bubble surface functionalization



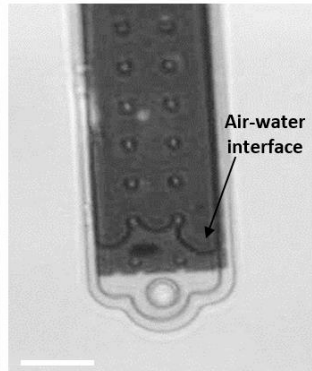
Pressure: 10 mbar
No bubble



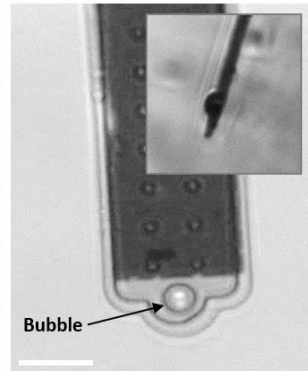
Pressure: -800 mbar
Liquid aspiration



Pressure: 200 mbar
Liquid release

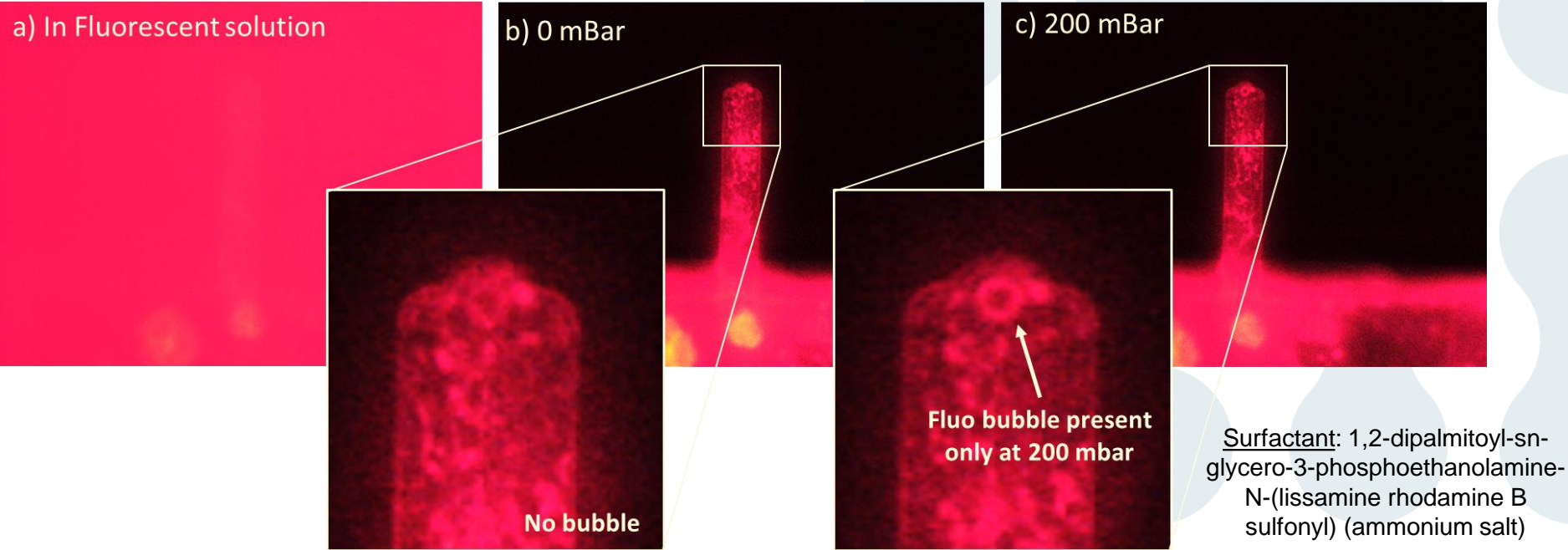


Pressure: 200 mbar
Bubble formation



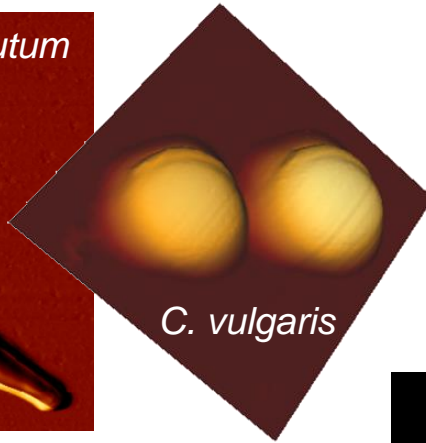
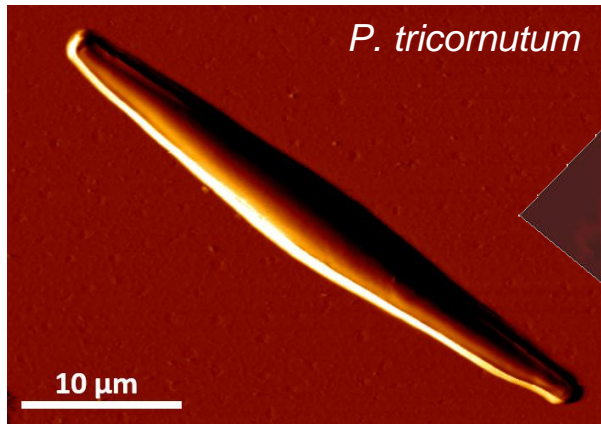
Possibility to aspirate surfactants and release them locally in a new liquid environment to produce functionalized bubbles

Production of functionalized microbubbles



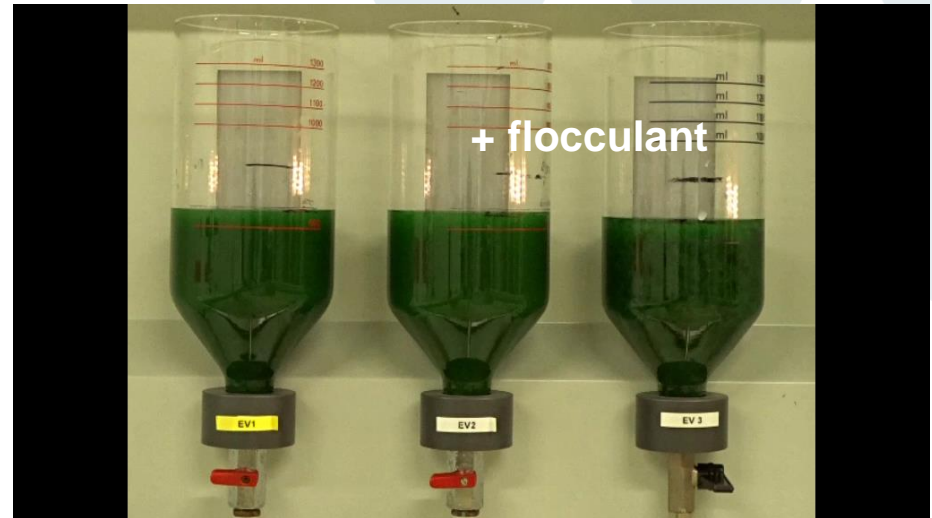
Functionalization of the surface of bubbles produced by FluidFM
⇒ **Possibility to control their interactions with cells**

Practical application: microalgae interaction with bubbles



- ▶ FLOTATION: cell capture by air bubbles rising in the microalgal suspension
 - ▶ Cheap and non-damaging technique
 - ▶ Challenging for microalgae, often need prior flocculation

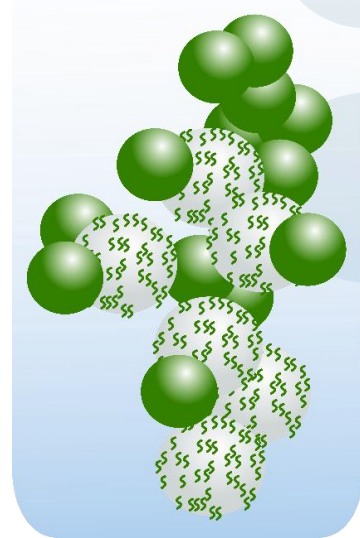
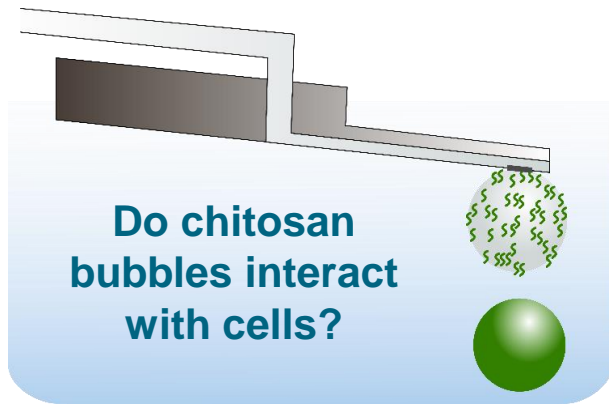
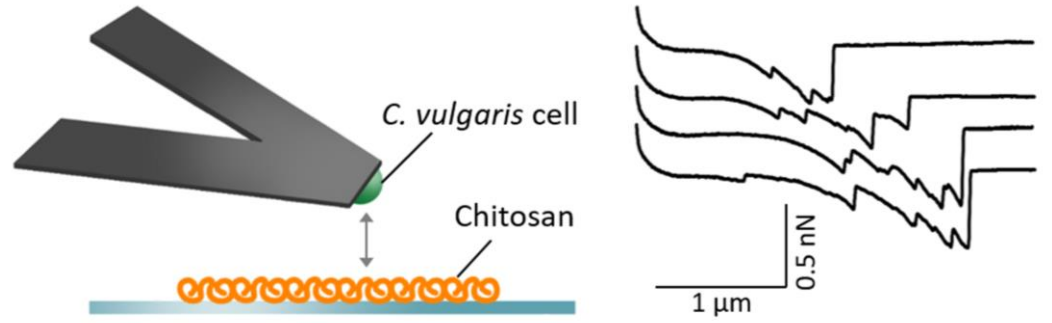
- ▶ Microalgae have great potential for food, feed, pharmaceutical and biofuels applications
- ▶ Their use is economically unviable because notably of the harvesting costs



Practical application: microalgae flotation chitosan

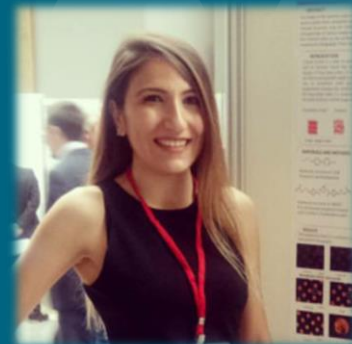
Chitosan, a natural flocculant, interacts specifically with the cell wall of *C. vulgaris*

Demir *et al.*, ACS Applied Bio Materials, 2020



Acknowledgements

TIM team of TBI



Irem Demir, PhD student



Thank you for your attention!



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