

# Preparation of biocompatible and antibacterial surfaces

C. Falentin-Daudré

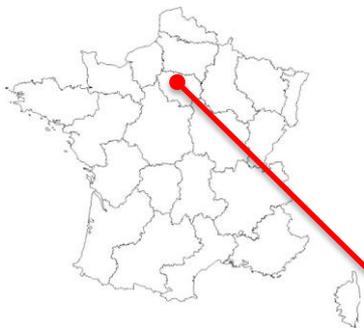


University of Sorbonne Paris North  
CSPBAT - UMR CNRS 7244  
LBPS Team

<https://cspbat.univ-paris13.fr/equipes/lbps.html>

# CSPBAT - UMR CNRS 7244

## Chimie, Structure, Propriétés de Biomatériaux et d'Agents Thérapeutiques



**NBD**  
Nano médecine  
Biocapteurs  
Détection

**CBS**  
Chimie  
Bioorganique  
et Synthèse

**LBPS**  
Biomatériaux  
Pour la Santé

**Direction de l'équipe LBPS:**

Dr C. Falentin-Daudré

**Enseignants-chercheurs:**

Pr S. Ramtani

Dr C. Falentin-Daudré (MCF-HDR)

Dr A. Rangel (ATER)

**BIATS:**

Dr JS Baumann (IE)

M. Lam (AI-doctorante)

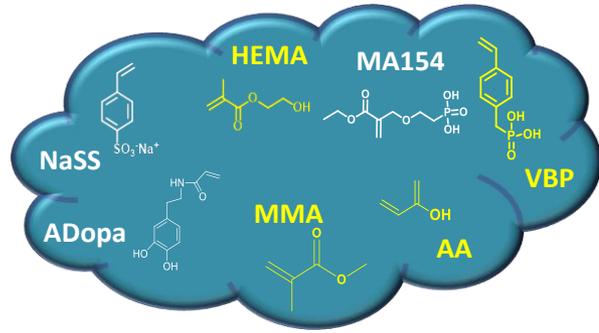
Dr M. Abdallah (IR)

E. Di Dio Busa (TC/BIATS)

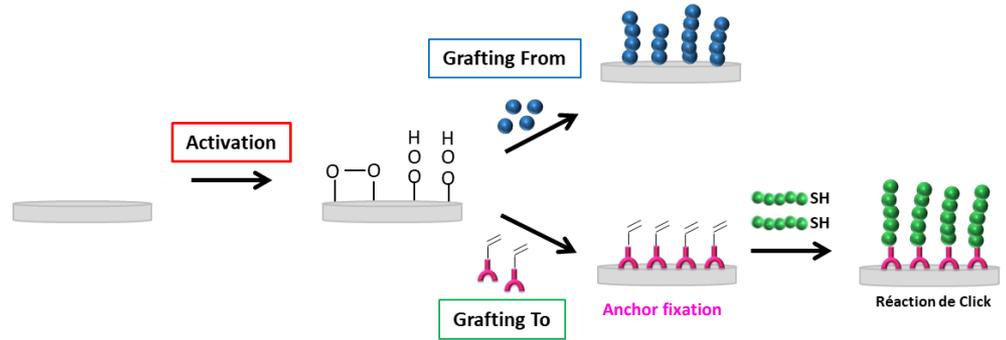
**Doctorants :**M. Lam (3<sup>ème</sup> année)V. Moris (3<sup>ème</sup> année)C. Pereira (2<sup>ème</sup> année)K. Benabdderrahmane (1<sup>ère</sup> année)A. Douhou (1<sup>ère</sup> année)F. Mouillard (1/2) (1<sup>ère</sup> année)

➤ **Team expertise** : Elaboration of antibacterial and biocompatible surfaces

--> **Functionnalization of biomaterials surfaces to improve the biological response**



Monomers synthesis



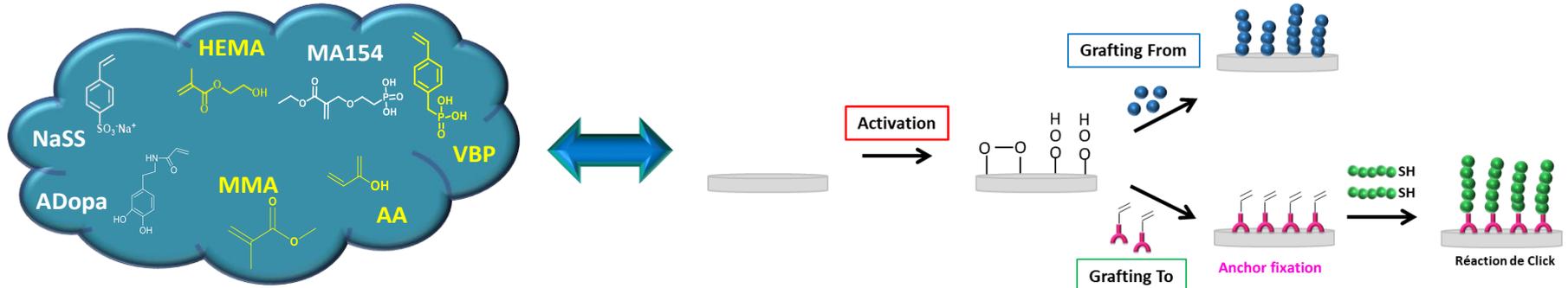
Grafting

*Surfaces : Polymers (PET, PCL, silicone),  
metals (Ti, alloys), ceramics (alumina, aragonite)*

- SEM-EDS
- AFM
- FTIR-ATR
- UV spectroscopy
- Contact angle measurement
- Colorimetry
- RMN
- SEC
- DSC

➤ **Team expertise** : Elaboration of antibacterial and biocompatible surfaces

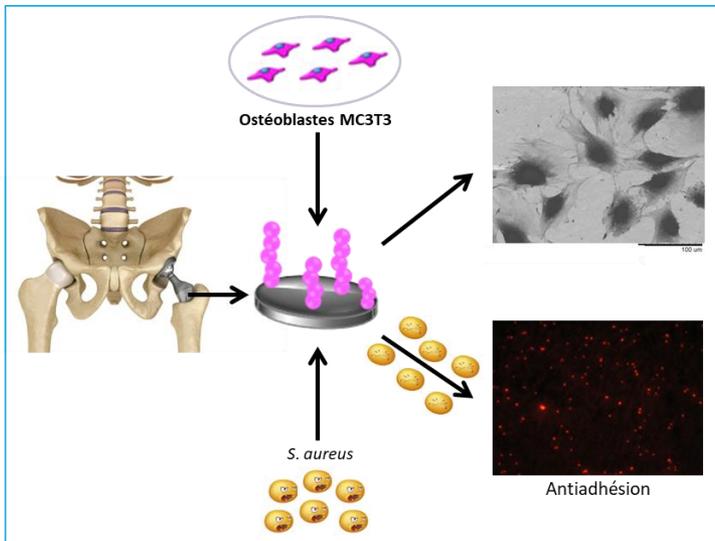
--> **Functionnalization of biomaterials surfaces to improve the biological response**



**Monomers synthesis**

**Grafting**

*Surfaces : Polymers (PET, PCL, silicone),  
metals (Ti, alloys), ceramics (alumina, aragonite)*



**Biological response**

--> Différents projets :

**Projet LIGA2BIO**



Dr A. Rangel

Elaboration d'une prothèse ligamentaire bioactive et biodégradable



**Projet Acollen**

Elaboration d'une colle biocompatible pour les tissus biologiques

**CONFIDENTIEL**



K. Benabdderrahmane



M. Lam





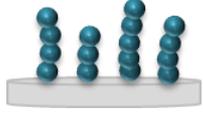
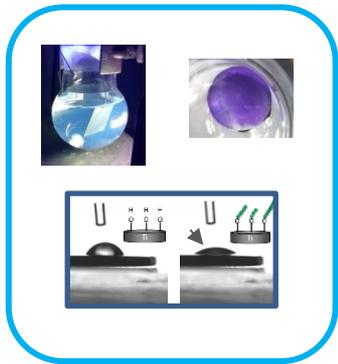
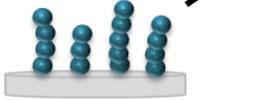
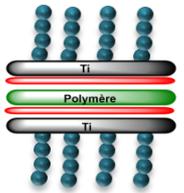
**Projet BIOSMS**

Thèse : C. Pereira

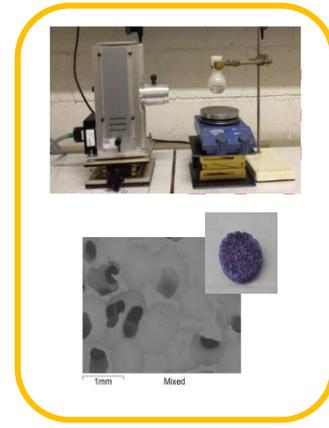
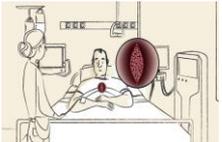


Pr A. Carrado Pr H. Palkowski

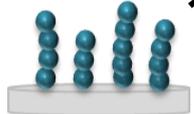
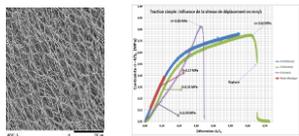
**Sandwich Ti/PMMA/Ti  
=> cranioplastie**



**Implant en alumine poreuse  
=> sternum**



**Membrane électrofilée  
en PCL**



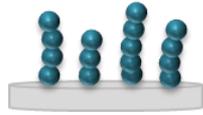
Thèse: K. Benabderrahmane



Dr JS Baumann Pr Ramtani

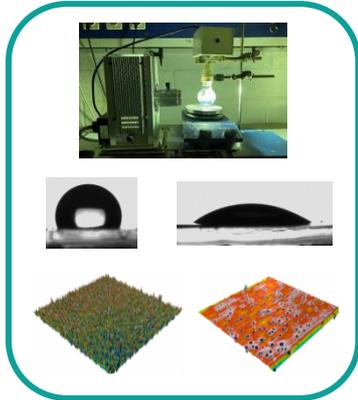
Thèse : A. Douhou

**Implant mammaire  
en silicone**



Thèse : M. Lam et Dr V. Moris

**Projet BIOACSIL**



# BIOACTIVATION OF SILICONE BREAST IMPLANT

## Collaborations :



Thèse : M. Lam et Dr V. Moris

## C. Falentin-Daudré



Dr. V. Humblot



Dr R. Vayron (LAMIH, Valenciennes)



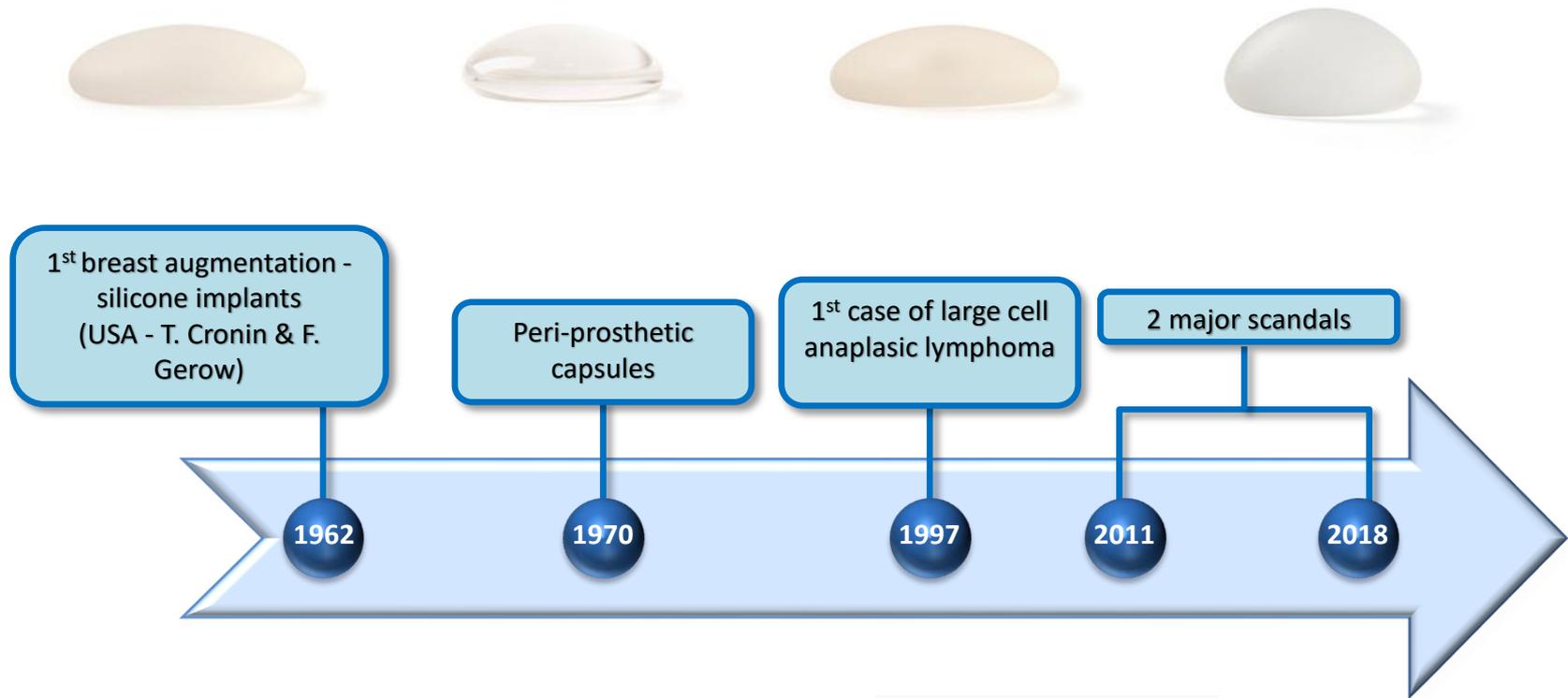
Dr C. Gomes (SEBBIN)



Dr N. Kerfant/ Dr M. Theron/Dr K. Pichavant (ORPHY, Brest)



Université Sorbonne Paris Nord  
Equipe « Laboratoire de Biomatériaux Pour la Santé (LBPS) »  
CSPBAT - UMR CNRS 7244



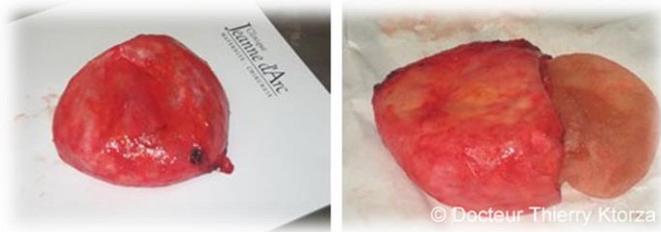
Cash Investigation  
« implants files »

## ① Capsular contracture

- Fibrosis
- Baker scale (stages I-IV)
  - Hardness
  - Pain
  - Skin deformation

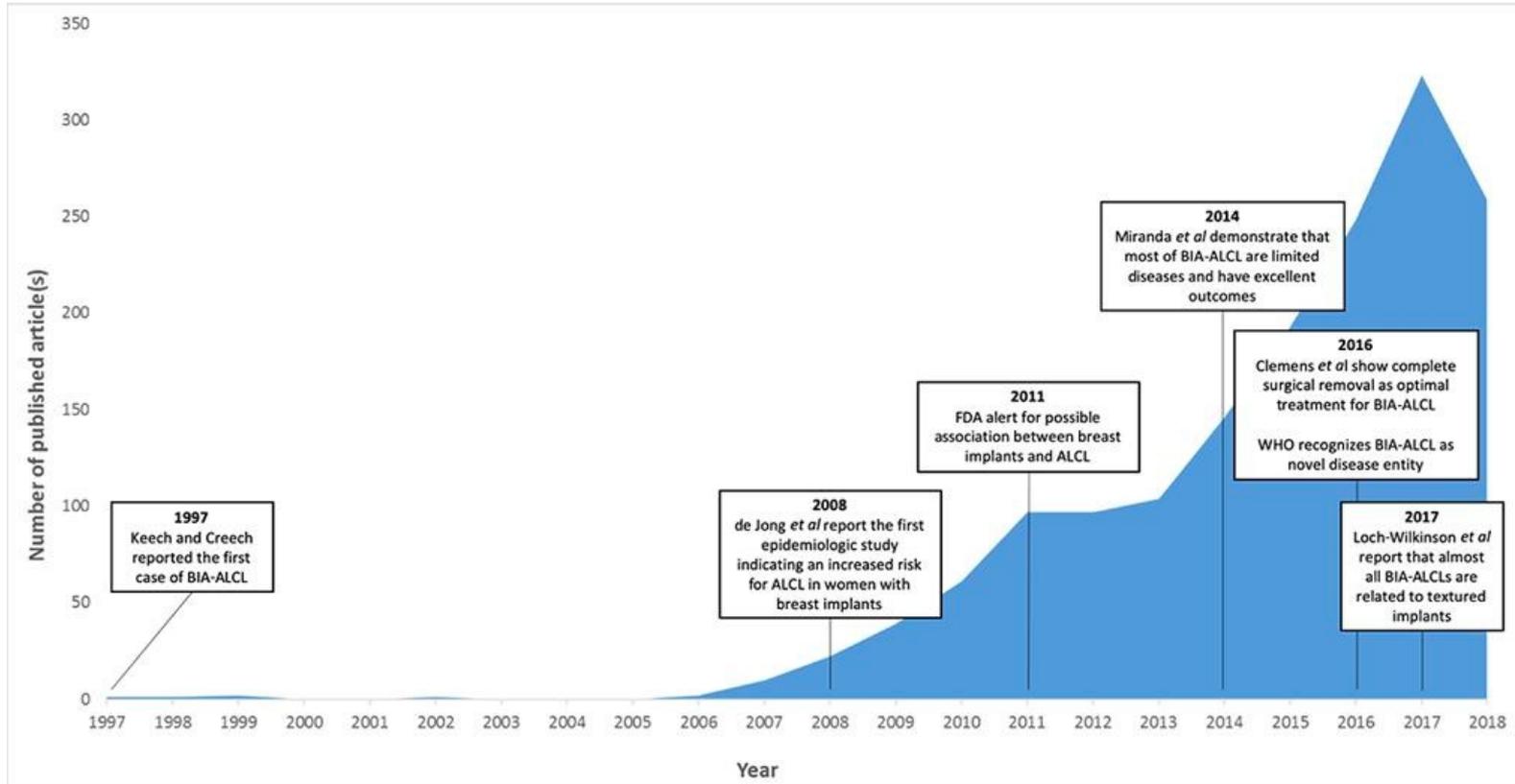
## ② Anaplastic Large Cell Lymphoma (BIA-ALCL)

- 953 cases worldwide (21/07/2020)
  - Long term apparition
  - Hardening, pain, skin deformation
- + Severe inflammation, fluids accumulation

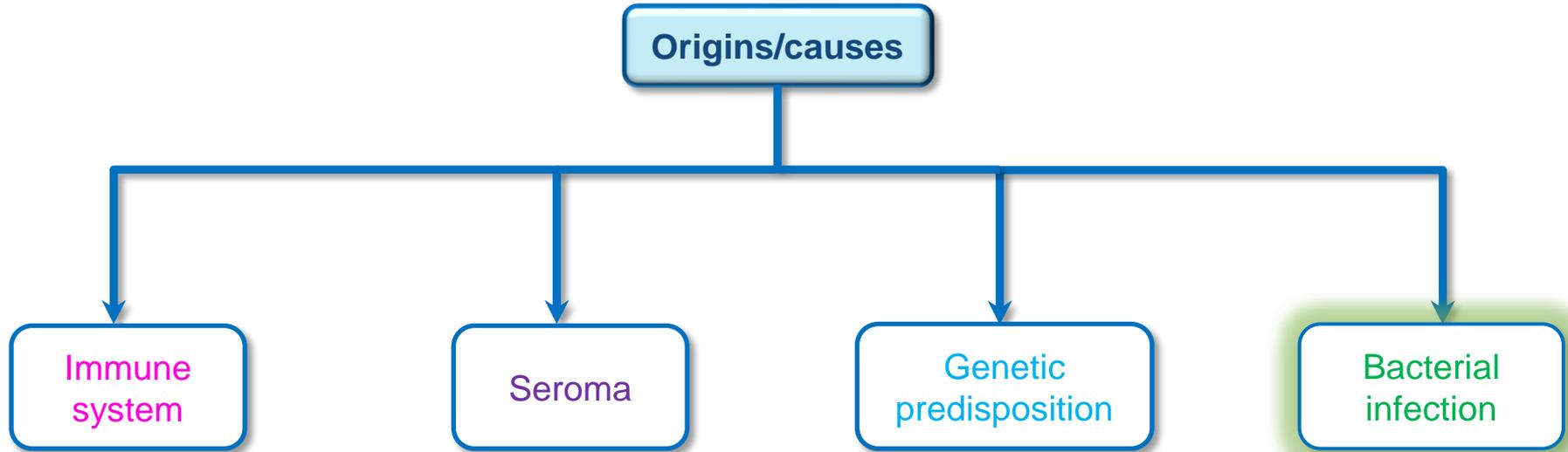


*Explanted breast implants*

⇒ **Removal and replacement  
(2<sup>nd</sup> surgery)**



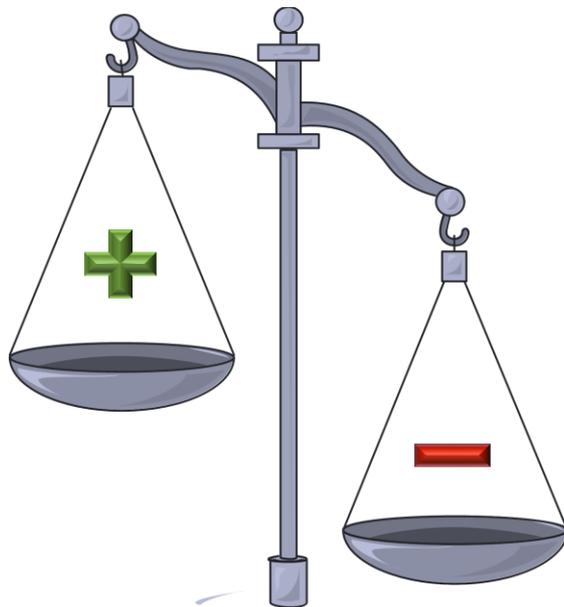
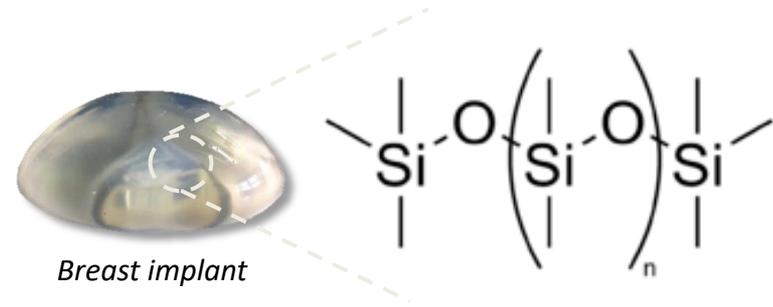
Marra, A.; Viale, G.; Pileri, S.; Pravettoni, G.; Viale, G.; De Lorenzi, F.; Nolè, F.; Veronesi, P.; Curigliano, G. Breast Implant-Associated Anaplastic Large Cell Lymphoma: A Comprehensive Review. *Cancer Treatment Reviews* 2020, 84, 101963.



- Explanted implants → High loads of *S. epidermidis*, *P. aeruginosa*, *R. pickettii*

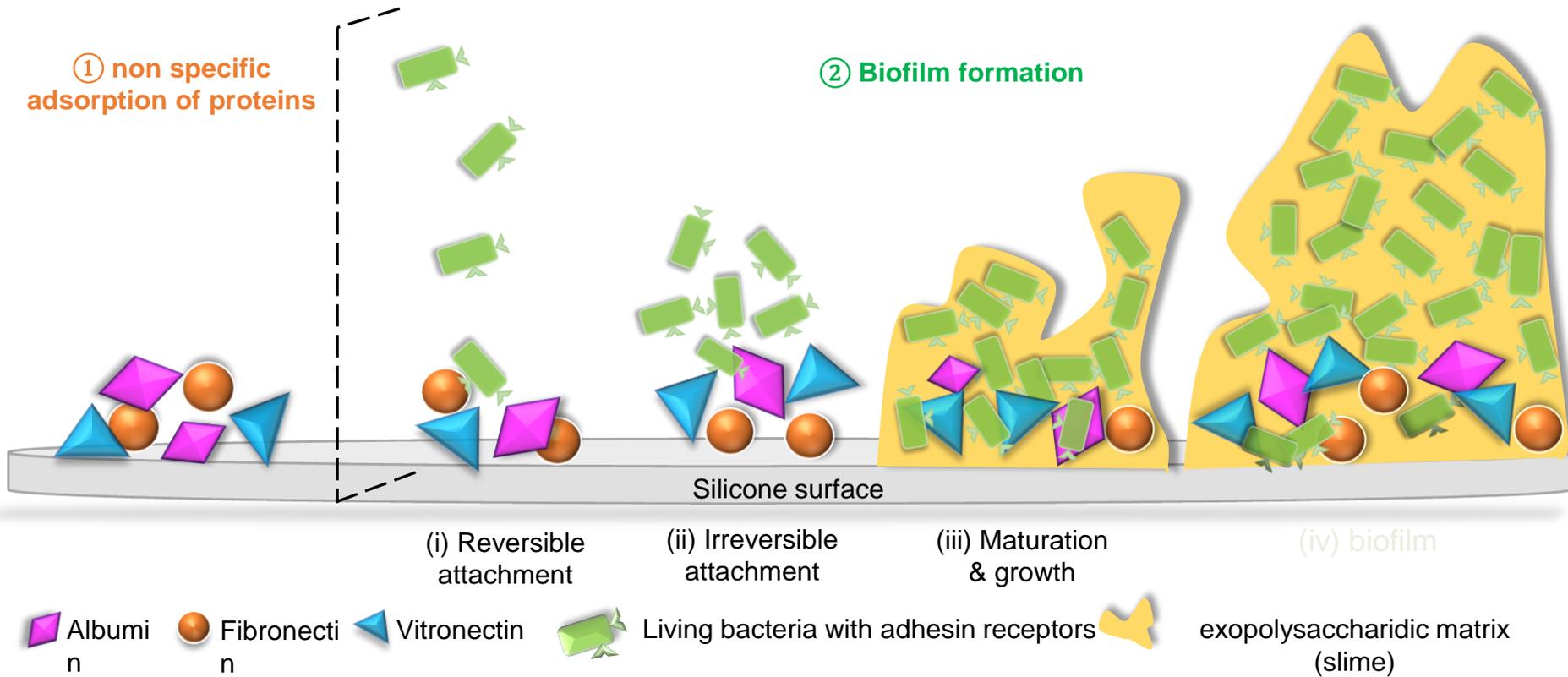
⇒ **BIOFILM**

- Also known as Poly(dimethylsiloxane) – PDMS
- Various physicochemical properties:



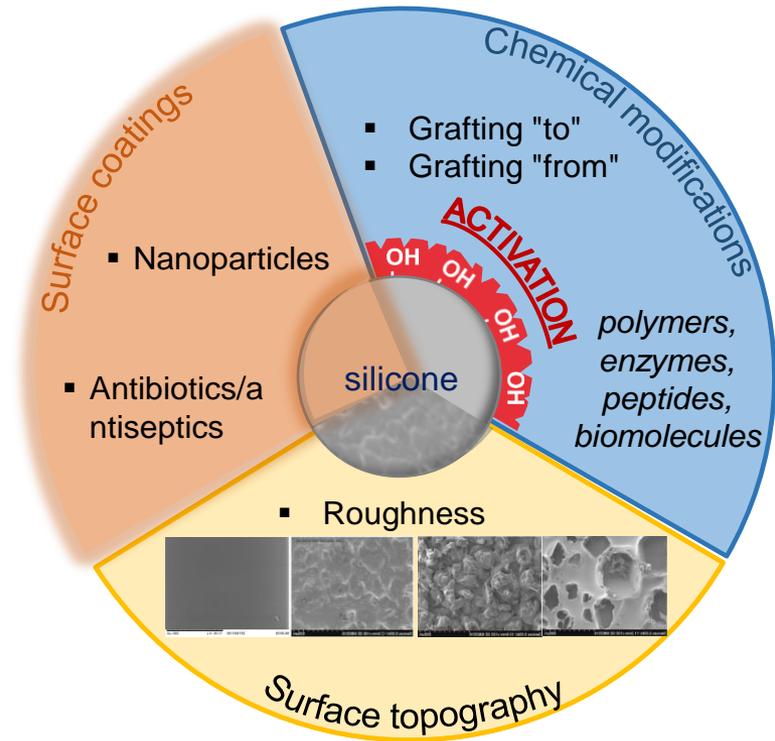
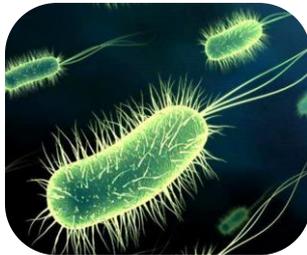
- Elasticity
- Transparency
- Low cost
- Ease to manufacture
- Biocompatible

- Hydrophobic
  - Inert
- ⇒ Prone to biofilm formation



- How to avoid/limit bacterial issues on silicone surfaces ?

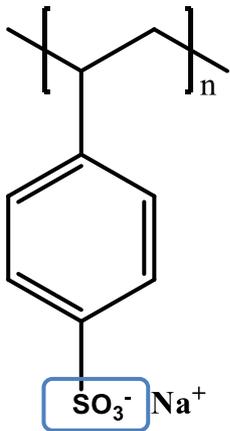
- Preventing biofilm formation
- Repelling bacteria
- Killing bacteria



- **LBPS team:** Using of bioactive polymers bearing carboxylate, sulfonate and phosphonate

➔ Acts on both problems : Cellular response / Bacterial response

- **Grafting « from » using polyNaSS :**



Polystyrene sodium sulfonate (polyNaSS)

Grafting of polyNaSS

- Hydrophilic
- Anti-bacterial surface
- Improved cell response
- Improved mineralization

on titanium (+ alloys) surfaces<sup>(1-3)</sup>

on polymers (PCL<sup>(4)</sup>, PET)<sup>(5)</sup>



(1) *Acta Biomaterialia* **2009**, 5, 124.  
 (2) *RSC Advances* **2016**, 6, 13766.  
 (3) *ACS Applied Materials & Interfaces*, **2018**, 10 (2), 1480.  
 (4) *ACS Omega*, **2019**, 4 (17), 17194.  
 (5) *Biomaterials* **2013**, 34 (29), 7048.

- Silicone-based materials

→ Synthesis of a silicone quater-polymer + bioactives groups (-COOH, -SO<sub>3</sub><sup>-</sup>)<sup>(1-4)</sup>

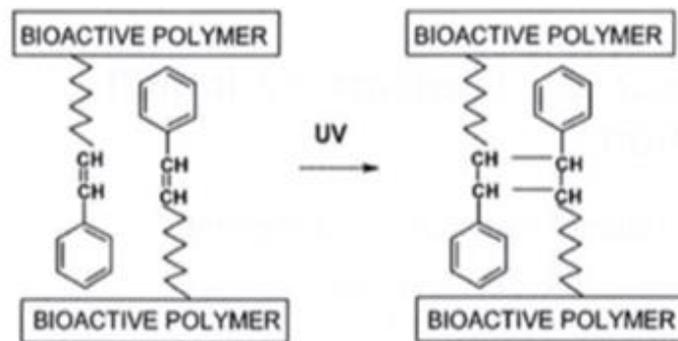


Pr. V. Migonney

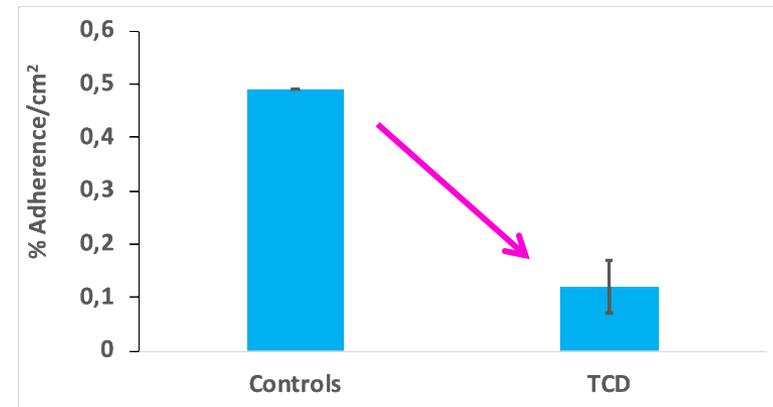


Pr. A-C. Crémieux

## 1 - UV mediated cross-linking



## 2- Bacterial adhesion tests



- *In vitro*<sup>(5)</sup>: Adherence inhibition of *S.Aureus* & MRSA 88244

→ **80%**

- *In vivo*: decreasing adherence

→ **1.5 to 2 log unit**

(1) *Biomacromolecules*, 2002, 3(1), 63-80.

(2) *Biomaterials*, 2006, 27(21), 3912-19.

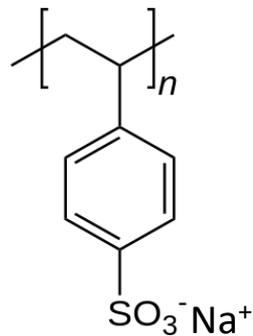
(3) *Journal of applied biomaterials & biomechanics*, 2003, 1(3):178-85

(4) *Biomacromolecules*, 2005, 6, 2630.

(5) *Biomacromolecules*, 2002, 3(1), 51-56.

## GOALS

- Improvement of the biological response
- Avoid/limit bacterial infections and biofilm formations



Polystyrene sodium sulfonate  
(polyNaSS)

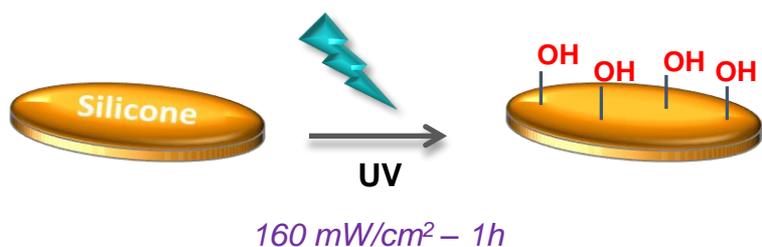
Direct grafting



Silicone breast implant

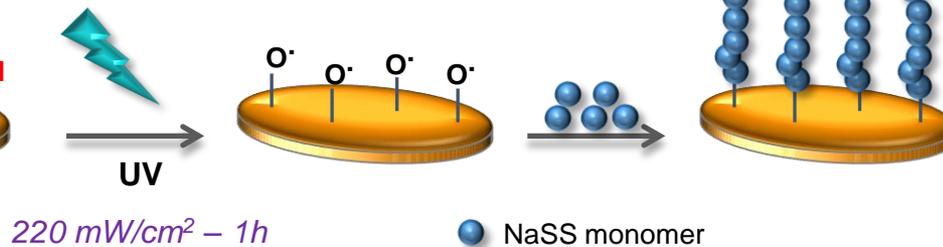
## 2-step UV-grafting mechanism

### ① ACTIVATION

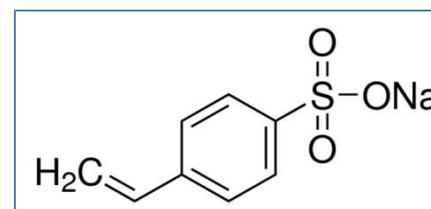


→ **Reactive groups formation**

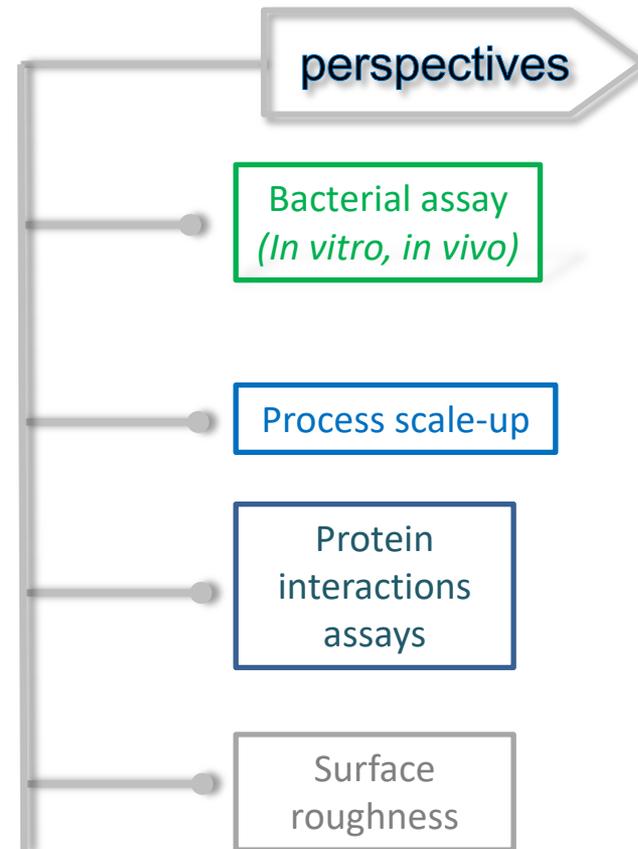
### ② SURFACE POLYMERIZATION



→ **Grafting « from » strategy**



- **Effective and easy grafting process**
- **Conservation of mechanical properties**
- **Promising cell response = biocompatibility**





M. Lam



Dr V. Moris



Dr R. Vayron



Dr R. Delille



UMR CNRS 8201



Dr V. Humblot



Dr N. Kerfant/ Dr M. Theron/ Dr K. Pichavant



Dr C. Gomes



Resp. de l'équipe : Céline Falentin-Daudré

Site web équipe : <https://cspbat.univ-paris13.fr/equipes/lbps.html>

Correspondant GDR : Céline Falentin-Daudré, [falentin-daudre@univ-paris13.fr](mailto:falentin-daudre@univ-paris13.fr)

### Mots-clés

Biomatériaux, polymérisation, greffage, bioactif, antibactérien, biocompatible



**Thank you for your attention**