Different strategies of composite material used by marine tube-building polychaetes

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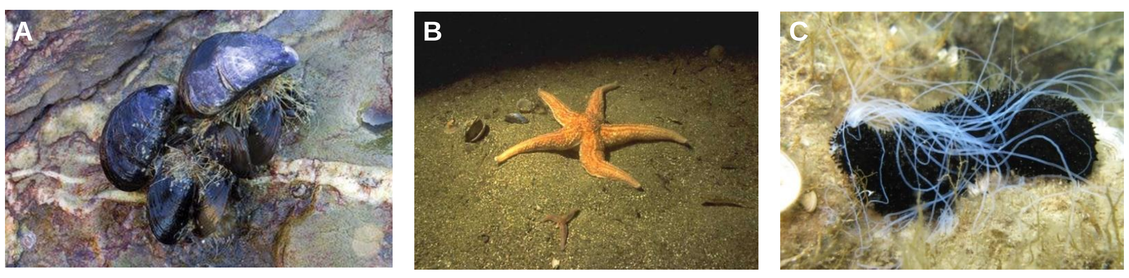
Objectives

In collaboration with the R&D team "Produits, Systèmes et Solutions", our project focuses on the identification and characterization of organic compounds used by tube-building Polychaete species for adhesion. Biomimetic approaches will be employed to adapt and transfer these new molecules and functions to develop novel Saint-Gobain moisture-resistant gluing materials.

Background

Diversity of adhesive systems in marine organisms

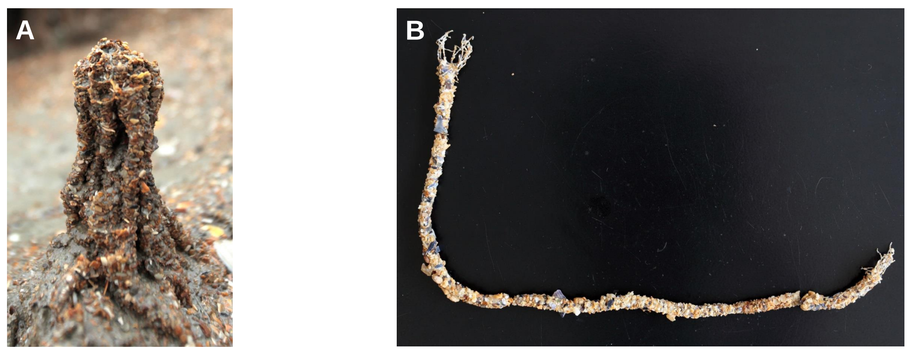
- Glues and adhesives inspired by marine organisms are a great source for biomimetic developments, and are likely to have multiple interests in industrial processes.
- To secure themselves on a substratum, sessile marine organisms elaborated diverse strategies of adhesion. Adhesion systems can be permanent, temporary or instantaneous. Biological compounds are able to interact with different types of biotic and abiotic surfaces.



(A) Mussels adhere to rock with a permanent adhesive, (B) sea stars adhere firmly but temporarily to various substrata by secreting a versatile adhesive, and (C) sea cucumbers release instantaneous adhesive Cuverian tubules as a defense against potential predators.

Permanent adhesion used by tube-building polychaete worms

Among the various marine organisms, some worm species of the Polychaeta phylum are capable of building flexible or rigid tubes serving as protective houses by assembling and gluing sand grains (siliceous particles) and clasts (calcareous particles).

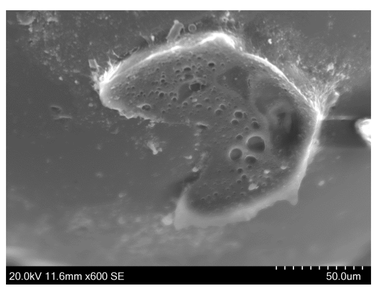


(A) Robust tubes constructed by a colony of *Sabellaria alveolata* individuals, (B) Flexible tube built by *Lanice conchilega*.

3D structure of the glue (SEM)

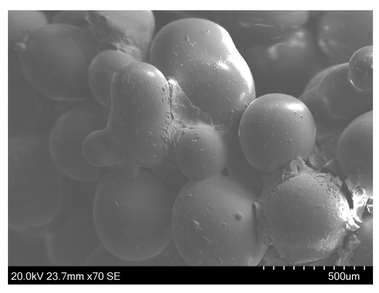
➢ **Rigid tubes**

Sabellaria alveolata



➢ **Flexible tubes**

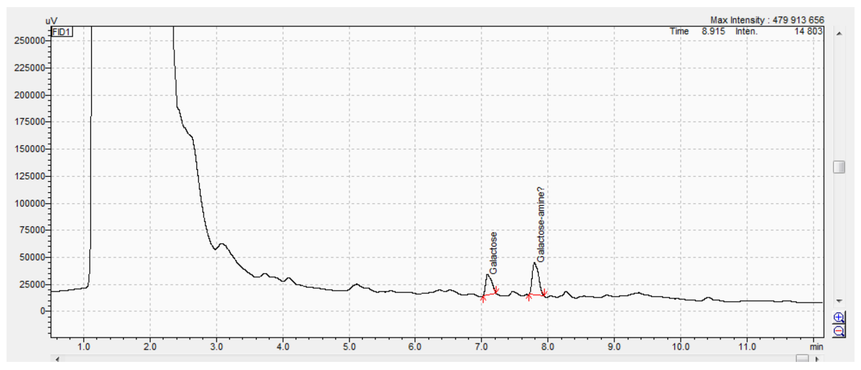
Lanice conchilega



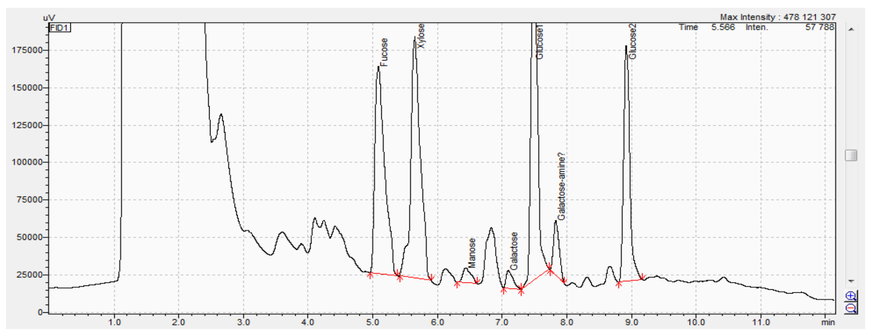
Cement discs of *S. alveolata* are round-shaped with pores of different sizes. *L. conchilega* glued the beads with a visco-elastic adhesive.

Identification of Carbohydrates

➢ **Rigid tubes**



➢ **Flexible tubes**



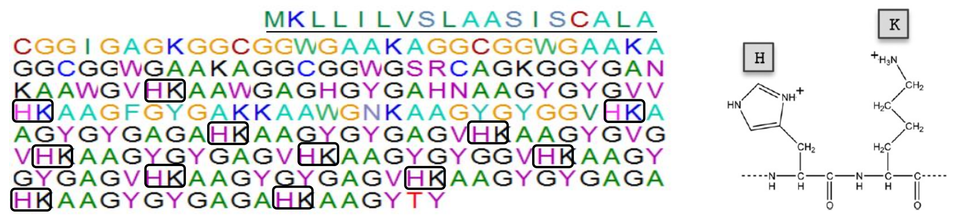
The adhesives secreted by *L. conchilega* (flexible tube) is composed of a greater diversity of monosaccharides than the ones of *S. alveolata* (rigid tubes).

Identification of adhesive proteins

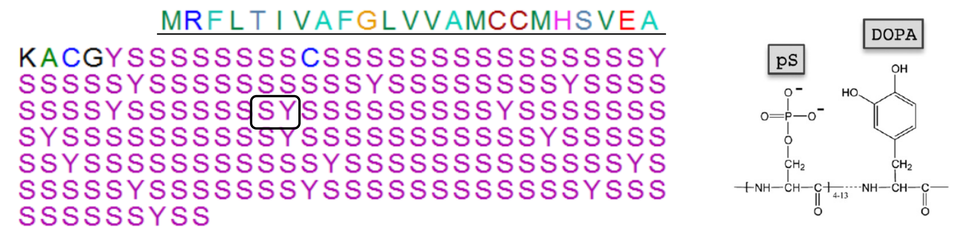
➢ **Rigid tubes**

Cement Protein	Features	*S. alveolata*
Total		80
GY-rich	DOPA, glycine- and tyrosine-rich, basic	10
H-repeat	Histidine rich, basic	8
Poly(S)	p-Ser (about 80 mol%), highly acidic	45
Hybride	DOPA, glycine-, tyrosine- and serine-rich, basic	17

H-repeat protein



Poly(S) protein



➢ **Flexible tubes**

Cement Protein	Features	*L. conchilega*
Total		41
La1	Calcium-binding protein	10
La2	Catalytic enzyme oxidizing phenol groups (peroxidase)	2
La3	Sugar-binding protein	4
La4	Catalytic enzyme degrading peptides (peptidase)	4
La5	Mucus	1
La6	Unknown	20

La1: Calcium-binding protein

The glue proteins of *L. conchilega* (flexible tube) are different from *S. alveolata* (rigid tubes).

Adhesive chemistry of Polychaetes' glue is achieved by modified amino acids alongside adhesive proteins

Perspectives

- **Glues secreted by Polychaetes building rigid and flexible tubes present different microstructure and biochemical composition offering a great resource for the development of wet and multipurpose biomimetic adhesives.**
- **We are elucidating the role and the function of novel cement-related proteins.**
- **Composition in polymers and proteins and their respective roles in the moisture resistance and mechanical properties of the bio-glue will be investigated.**
- **We are testing the impact of environmental conditions on the formation and organic composition of flexible tubes in *L. conchilega*.**