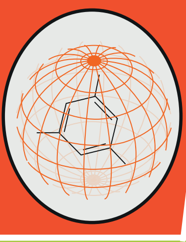
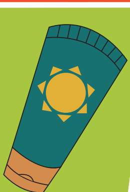


Safe(r) by design sunscreen

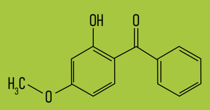
A MIXING OF UV FILTERS



Protecting our skin from UV rays is essential to avoid skin cancer. Most of sunscreen are composed of a mixture of 2 types of UV filters:

Organic filters are composed of **molecules**

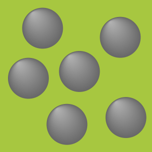
Size: **less than 1 nm**



Oxybenzone

Mineral filters are mostly composed of **TiO_2 nanoparticles (NPs)**

Size: **below 100 nm**



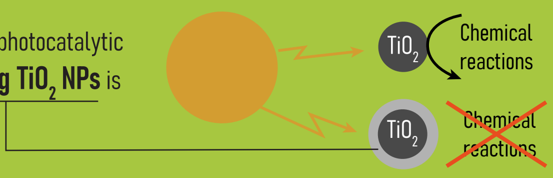
Organic UV filters allow to select specific UV ranges but they are rapidly degraded, mineral filters help to **increase sunscreen durability**.

TIO_2 PROPERTIES IN MINERAL FILTERS

TiO_2 nanoparticles (NPs) have **2 main properties**:

- **absorb UV rays**, they are used as UV filters and protect our skin,
- **photocatalytic activity** which damages and burns our skin.

To protect from photocatalytic activity, **coating TiO_2 NPs** is essential.



The environmental fate of these coated TiO_2 is still unknown.

Are these nanoparticles stable?

OBJECTIVE

Optimizing the sunscreen formulation thanks to safe(r) by design strategies:

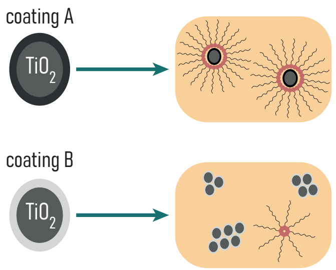
- **enhancing the dispersion of TiO_2 NPs in the sunscreen, to reduce the quantity needed,**
- **analyzing the stability of the coating and the environmental impact of coated TiO_2 NPs.**

SOME RESULTS OF THE PROJECT

Optimizing NPs dispersion to reduce the amount needed

Sunscreen is an **emulsion** between water and oil, the presence of **surfactants** is thus inevitable.

Interactions between coated TiO_2 NPs and other ingredients have been analyzed to better understand the NPs dispersion. Here **several combinations of TiO_2 NPs coating/sunscreen ingredients** have been analyzed.

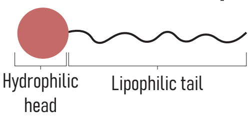


Some combinations of TiO_2 NPs coating/surfactant have a **higher affinity**.

This leads to a **better dispersion** in the emulsion and a **reduction of NPs quantity needed** in the final product.

Information

A surfactant component is **amphiphilic**:



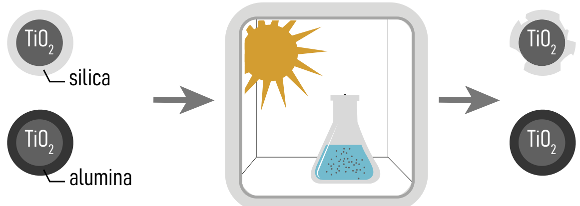
It helps the **dispersion** of:

an hydrophilic component in an oil phase

an hydrophobic component in a water phase

Analyzing the stability of different TiO_2 coatings

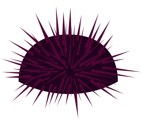
Different coatings have been tested on TiO_2 NPs. They were **aged in a climatic chamber** with light control to mimic their fate in the environment.



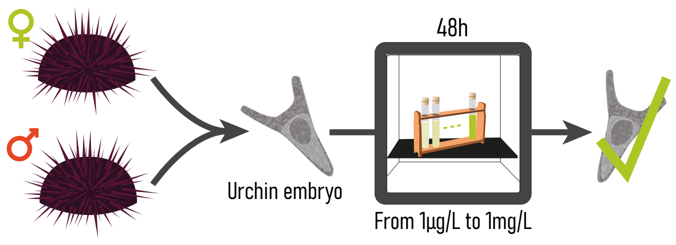
Alumina provides a more durable **protection against photoactivity** than silica. The environmental hazards of these aged NPs need to be analyzed.

Assessing the impacts of these NPs for marine species

Paracentrotus lividus is a **relevant sentinel of environmental stress**, it is found in almost all marine environments. It is an interesting model organism.



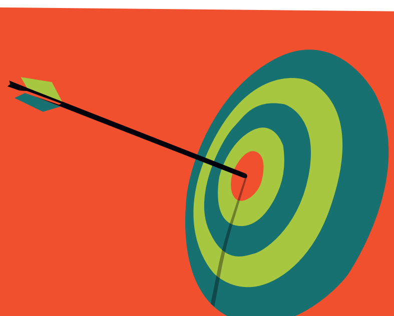
Impacts of coated TiO_2 NPs (with alumina or silica) have been tested using **environmentally revelant concentrations** according to literature (1 µg/L) and **extreme concentrations** (1 mg/L).



From 1 µg/L to 1 mg/L, coated TiO_2 NPs **do not cause significant harmful effects** on the embryonic development of sea urchins. Further experiments show that they are **not toxic for immune cells** either.

To limit the potential impact of TiO_2 on human health and the environment, two strategies have been developed:

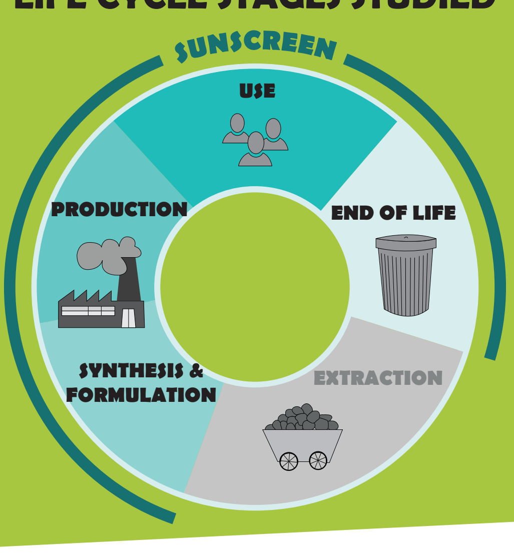
- optimal combination of TiO_2 NPs/surfactant ⟶ **maximal dispersion**
- durability of TiO_2 NPs coating ⟶ **limit photocatalytic activity** over time



Alumina coating enables finer NPs dispersion with the studied surfactant and is more resistant to aging than silica.

These experiments allow to **consider new options to develop a safe(r) by design sunscreen**.

LIFE CYCLE STAGES STUDIED



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Serenade
Safe(r) Ecodesign Research and Education applied to NAnomaterial DEvelopment.

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Investissements d'avenir

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