Polymer and emulsions in the formulation of biocontrol agents

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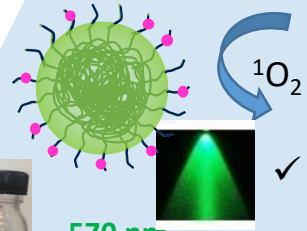
Polymer for Sustainable Chemistry

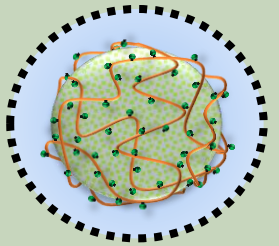
Functional Polymer Colloids



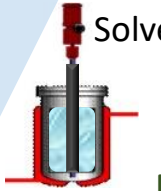
Supported organic photocatalyst

- ✓ Photooxydation **biobased** molecules
- ✓ Recycling photocatalyst
- ✓ **Bactericidal** coatings (photodynamic inactivation in collab. P. Fernandez)

Synthesis of Biobased polymers



- ✓ **Polysaccharide and TERPENES : Emulsifiers** (oil/water emulsion), waterborne **latex** for **coatings**
- ✓ **Encapsulation of natural extracts for biocontrol in crop protection**



Solvent-free

Light-activated

Eco-friendly processes

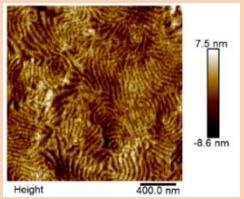
Biomass feedstock

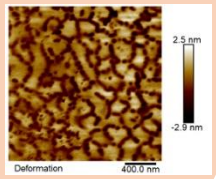
Encapsulation of active molecules

Environmental monitoring

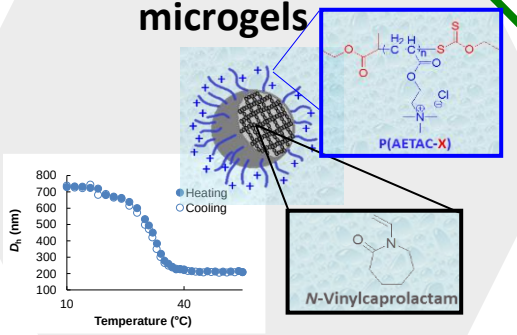
Nanostructured polymer materials:

Transparent films, Shock impact resistant, Biobased, 3D printing (Collab. L. Rubatat)



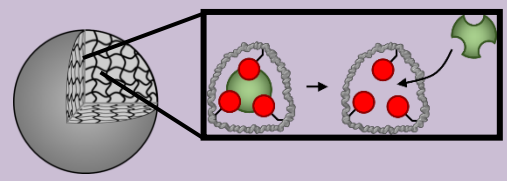


Thermoresponsive microgels



Molecularly Imprinted Polymer (MIP) colloids / MICROGELS

Water-compatible **selective** solid phase extraction (SPE) of **organic pollutants**



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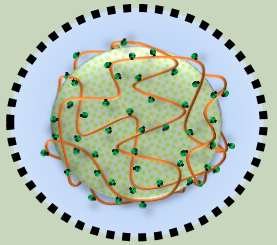
Polymer for Sustainable Chemistry

Biomass feedstock

Synthesis of Biobased polymers



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- ✓ **Encapsulation of natural extracts for biocontrol in crop protection**

Biocontrol in a few words

Biocontrol brings together various solutions that present limited risks to human health and the environment, as an **alternative to conventional phytosanitary products**, especially those of greatest concern, intended **to protect crops** against diseases, crop aggressors (pests, insects, viruses, bacteria, mites, etc.) and weeds.

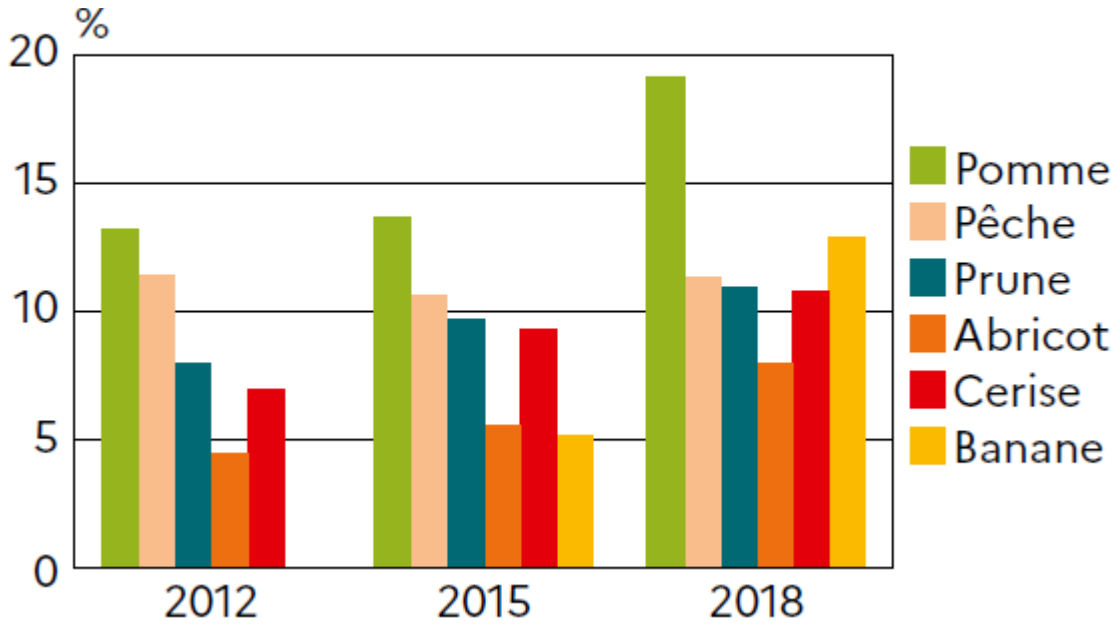
Biocontrol methods are based on mechanisms and interactions that exist in nature.

https://agriculture.gouv.fr/quest-ce-que-le-biocontrole

Proportion of use of biocontrol products in France

Arboriculture - Fruits

Part of biocontrol IFT based on total IFT



The **Phytosanitary Treatment Frequency Indicator (IFT)** = number of reference doses used per hectare calculated for a set of plots, a farm or a territory.

Source: rapport Graph'agri 2023

Proportion of use of biocontrol products in France

Vegetables

7 % for les carrots

6% for open field tomatoes

37 % for greenhouse tomatoes & soil-less tomatoes

IFT* moyen en 2022

Espèce	Mode de conduite		Herbicide	Fongicide	Insecticide	Autre	Traitement semences et plants	Bio-contrôle*	IFT Total
Carotte	Ensemble[1]		2,5	2,4	1,1	0,3	0,7	0,5	7,0
Chou de Bruxelles	Ensemble		0,9	3,3	5,1	ns	0,4	ns	10,1
Chou feuille[2]	Ensemble		0,5	0,8	1,4	ns	0,7	0,1	3,5
Chou à inflorescence	Ensemble		ns	0,6	ns	ns	0,8	ns	2,2
Fraise	Pleine terre	Plein air ou abri bas	0,1	2,2	1,0	ns	0,2	0,4	3,7
		Sous serre ou abri haut	0,0	2,6	1,8	0,1	0,4	0,5	4,9
	Hors sol		ns	3,8	ns	ns	0,7	0,8	7,0
	Ensemble		0,0	3,0	1,8	0,1	0,5	0,6	5,4
Melon	Pleine terre	Plein air ou abri bas	0,1	3,2	0,8	0,2	0,7	1,0	5,0
		Sous serre ou abri haut	ns	0,8	0,9	ns	0,6	ns	2,3
	Ensemble		0,1	3,1	0,8	0,2	0,7	1,0	4,9
Oignon	Ensemble		2,0	5,7	0,8	0,5	0,7	ns	9,6
Potiron	Ensemble		0,0	0,2	ns	ns	0,2	0,1	0,6
Salade chicorée et laitue	Pleine terre	Plein air ou abri bas	0,7	1,6	1,7	0,2	0,6	0,3	4,8
		Sous serre ou abri haut	ns	3,1	1,8	ns	0,7	ns	6,0
	Ensemble		0,6	1,9	1,7	0,2	0,6	0,4	5,0
Salade mâche	Ensemble		0,6	0,6	ns	0,0	0,7	ns	2,0
Tomate	Pleine terre	Plein air ou abri bas	1,2	4,0	2,3	0,0	0,6	0,5	8,2
		Sous serre ou abri haut	0,0	1,5	1,6	ns	0,5	1,4	3,7
	Hors sol		0,0	1,7	2,5	ns	0,8	2,0	5,3
	Ensemble		0,6	2,9	2,3	0,1	0,7	1,1	6,5

Source: rapport Graph'agri 2025

4 groups of biocontrol solutions:

- Biocontrol agents of the macroorganism type (e.g. ladybird which is a natural predator of aphids).
- Biocontrol crops protection products, which include three categories of active ingredients:

  - **Microorganisms** (bacteria, viruses, fungi)
  - **Chemical mediators** (including pheromones)
  - **Natural substances** (mineral, animal or vegetable origin)

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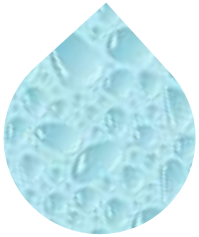
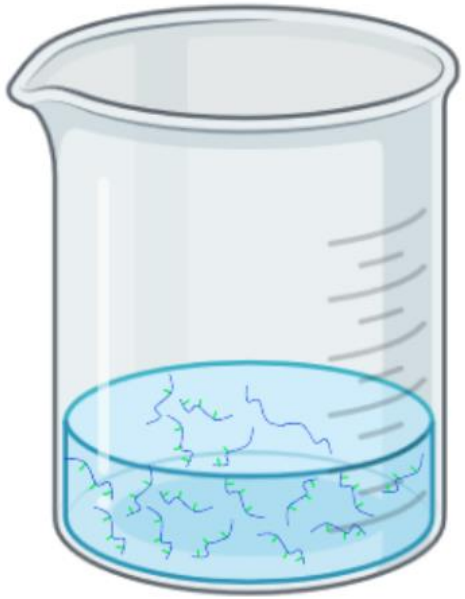
⇒ Some products that are insoluble in water but lipophilic (soluble in oil)

⇒ Need to **formulate** products to **disperse in water** to facilitate user spraying/spreading



Interest of formulations based on Oil-in-Water liquid EMULSIONS

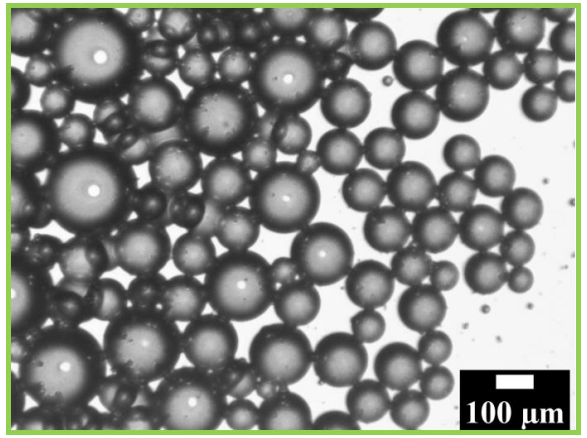


Aqueous phase
+ emulsifier

+

Oil phase + liposoluble biocontrol active ingredient

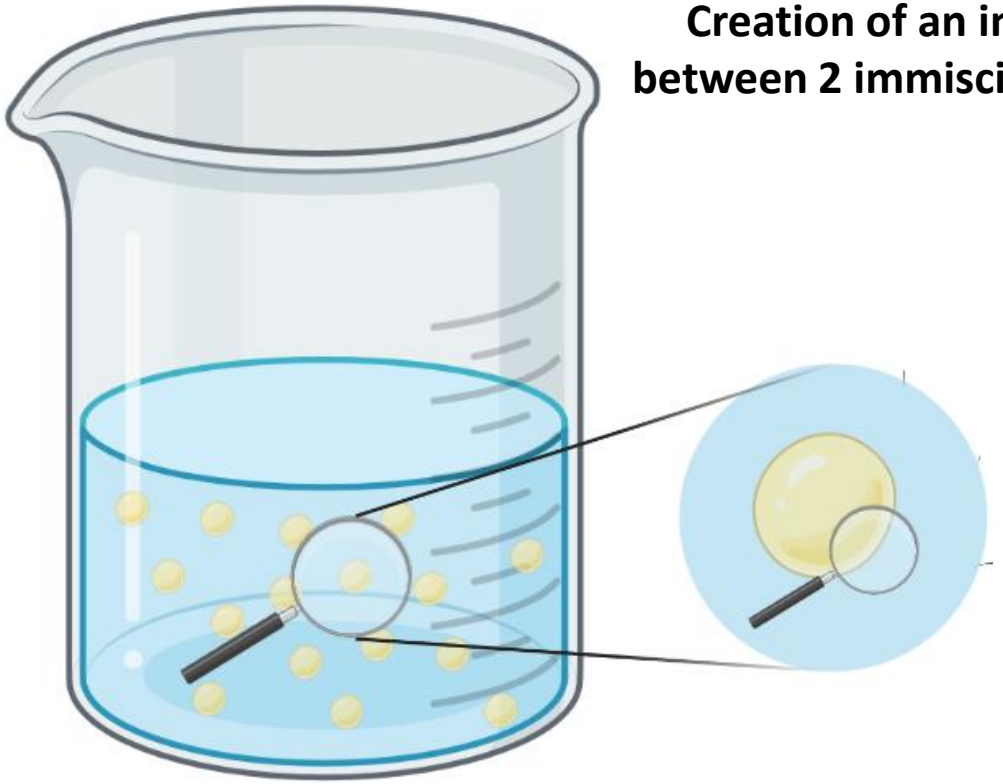
Oil-in-water emulsion



- **Encapsulation of the active ingredient in oil drops**
- Continuous phase = water
- Facilitate post-dilution in water before use (spraying ..)

Oil-in-water emulsion

Creation of an interface between 2 immiscible liquids



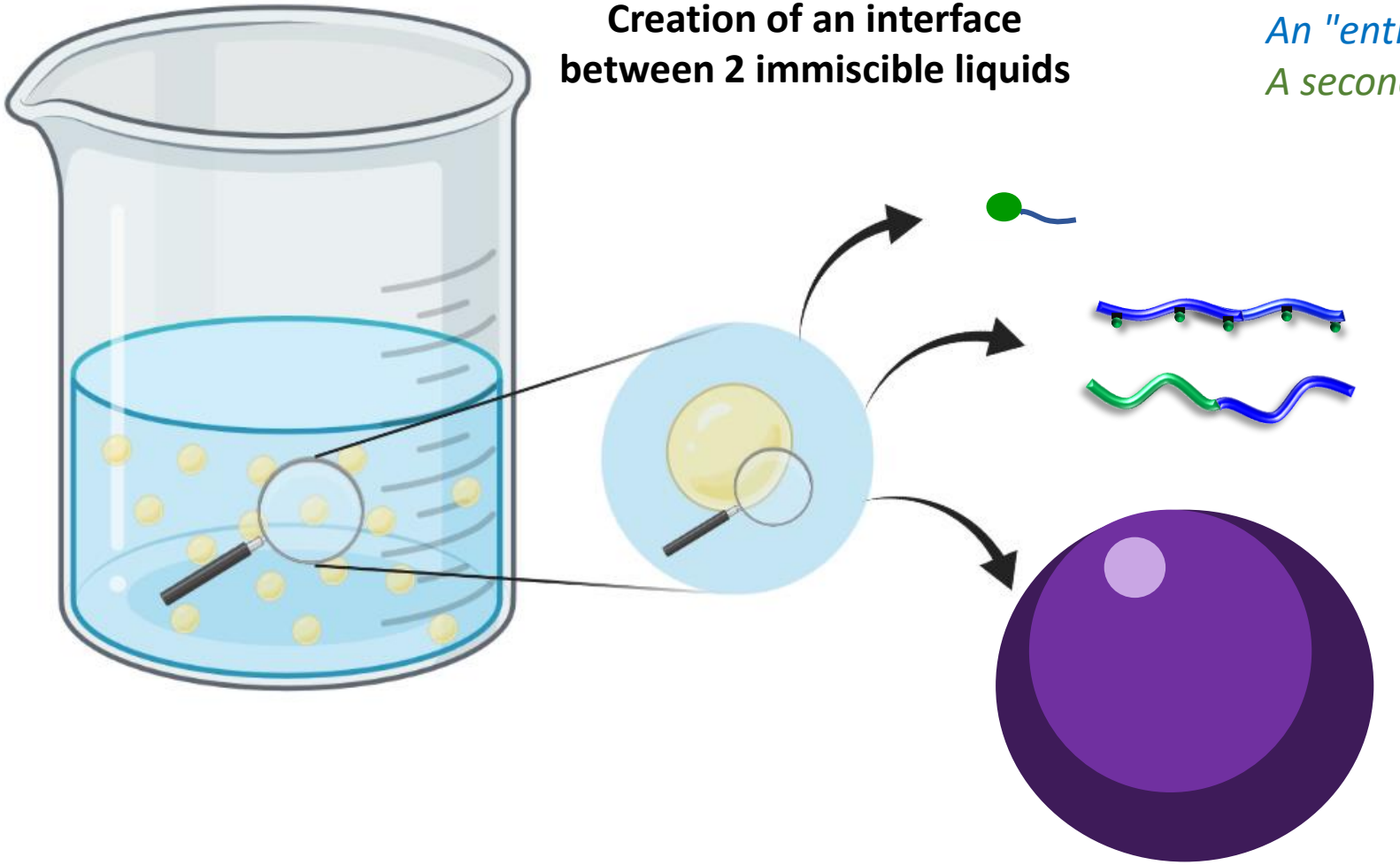
Oil-in-water emulsion

⇒ **Role of emulsifiers / stabilizers in reducing surface tension**

Creation of an interface between 2 immiscible liquids

An "entity" has an affinity for water

A second "entity" has an affinity for oil



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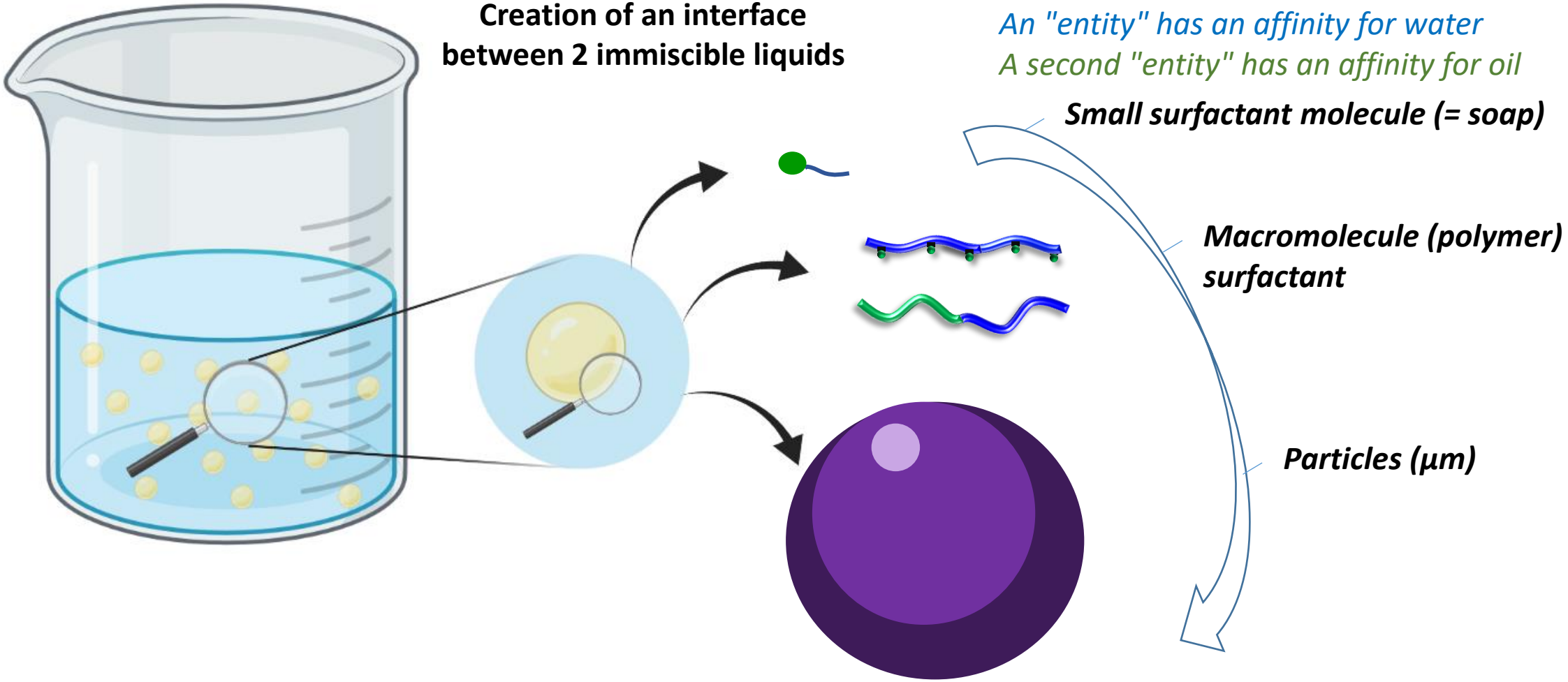

Increased size, increased stability of the emulsion over time (storage)

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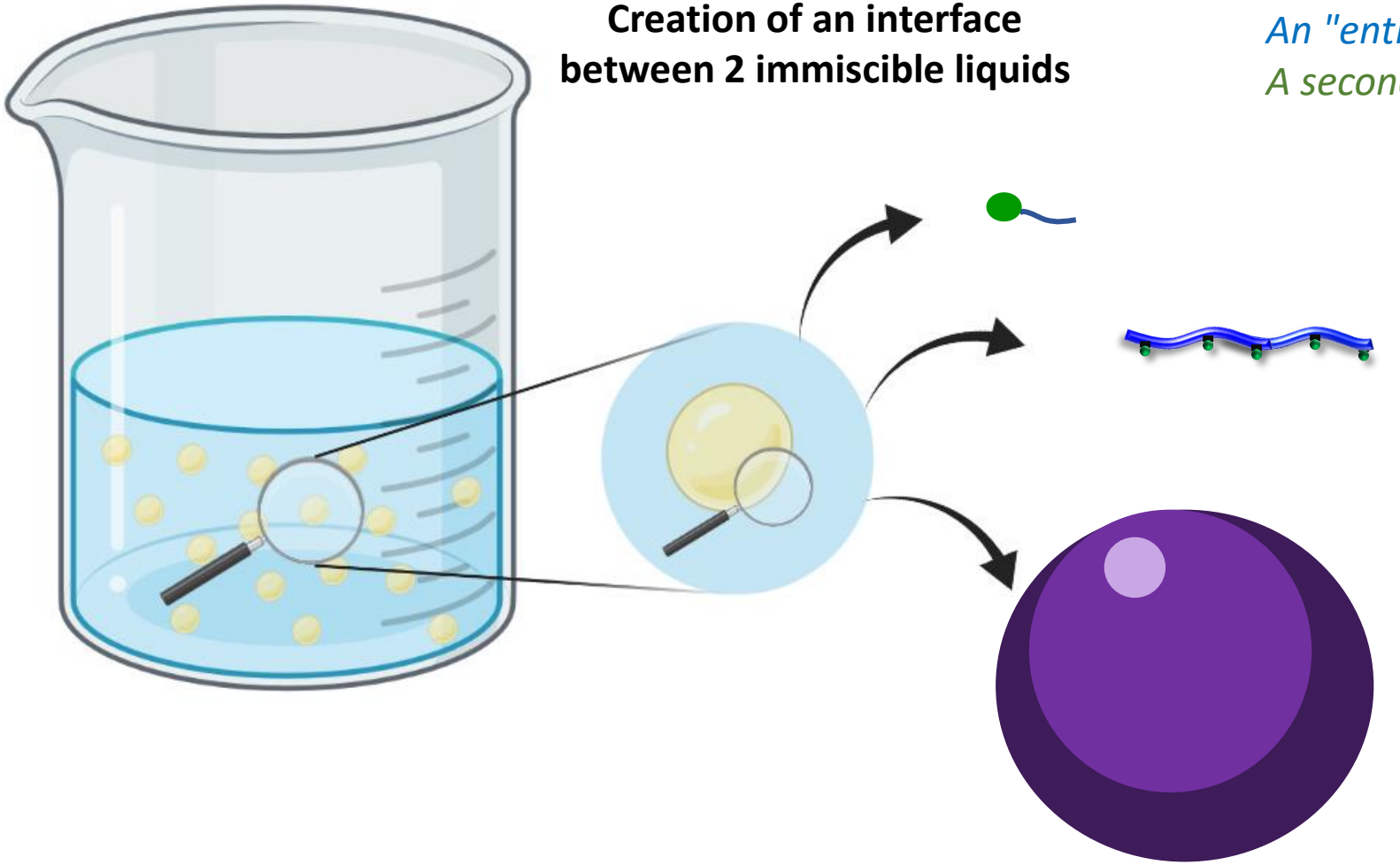


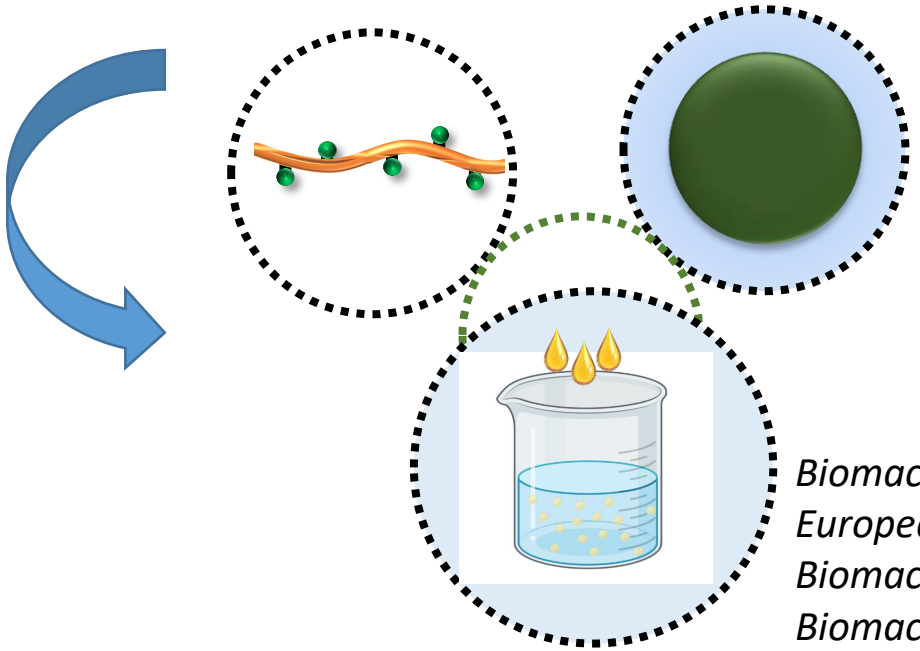
< 5 % by weight of the total formulation

Increased size, increased stability of the emulsion over time (storage)

Emulsion formulations and biocontrol

1. Design of bio-based emulsifiers : polymer or polymer particles

2. Stabilization of O/W or W/O emulsions



Biomacromolecules **2014**, 15, 242.
European Polym. Journal **2017**, *94*, 248
Biomacromolecules **2022**, *23*, 2536.
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2020 – 2024
8 partners
(4 industrials partners)

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

Encapsulation of bioactive extracts for crops protection⇒ BIOCONTROL solution

(collab. CRPP Univ Bordeaux V. Schmitt)

BIOCOLPIC Project
2018 – 2021
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Formulation of Emulsions

Pheromone encapsulation

M2i, Lead the Change

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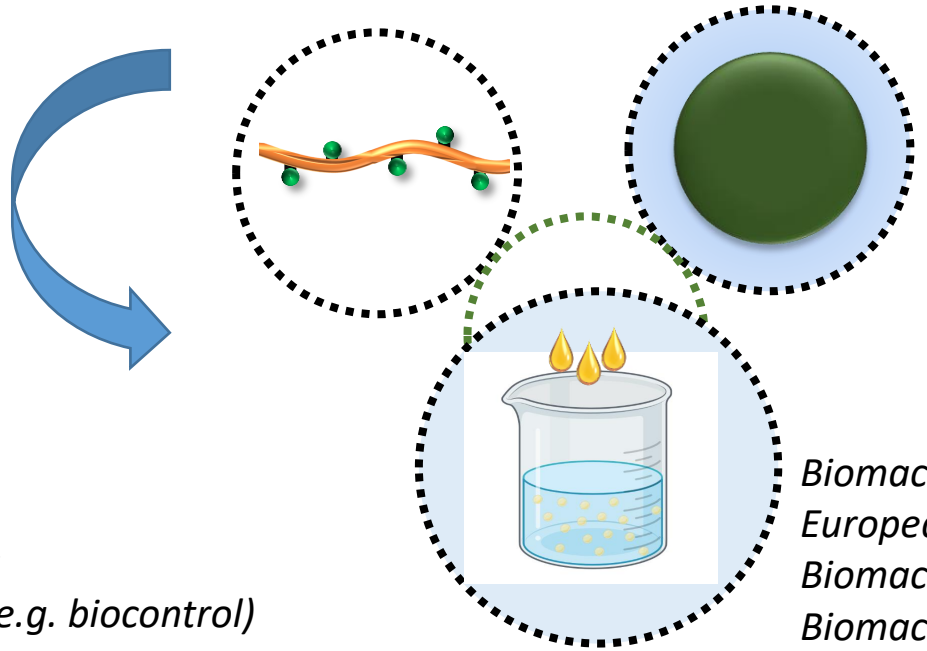

Challenges adressed

- *Possibility of preparing emulsions?*
- *Study of stability over time*
- *Encapsulation Efficiency of active product*
- *Efficacy of the formulated product after spray on crops (e.g. biocontrol)*

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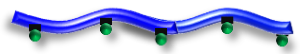
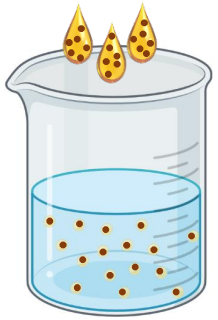
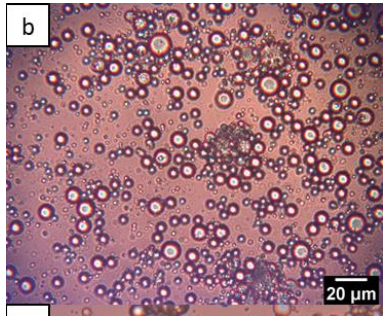
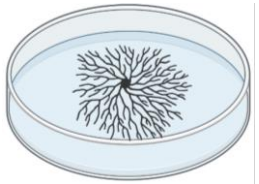


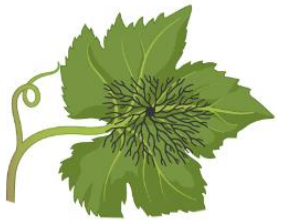
2 Formulation of emulsions: encapsulation of natural extract of plants





3 Preventive treatment: study of antifungal activity against bacterial strains





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Emulsion formulations and biocontrol

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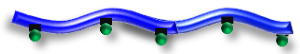
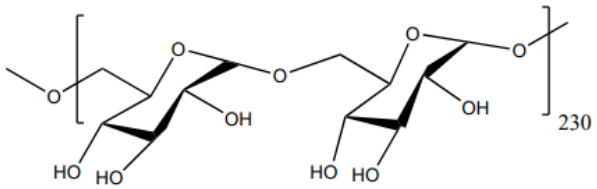


Hydrophilic part
Natural Polysaccharide
or biobased Polyacrylics

Hydrophobic part
Terpenes from Pine trees
(not in competition with food supply chain)



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2

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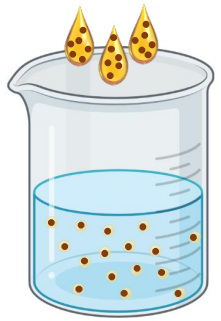
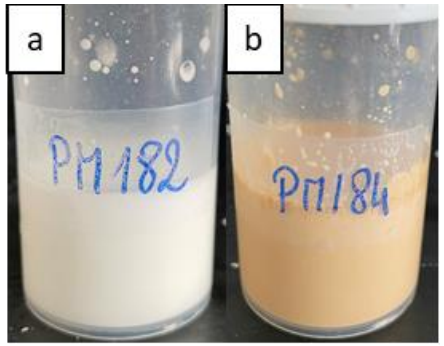
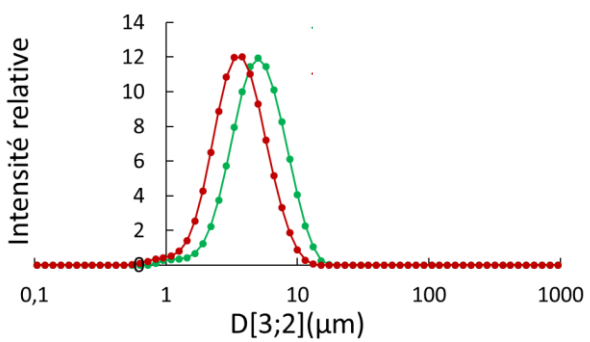




Oil droplet diameter



4 – 6 months of stability of control emulsion and emulsion with natural extract

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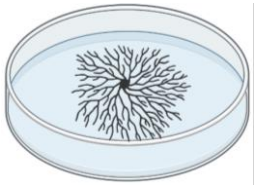
Emulsion formulations and biocontrol

3 **Preventive treatment**: antifungal activity (under confidentiality)



4 days after inoculation of plant pathosystem: 60% to 90% of Fungi growing reduction

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