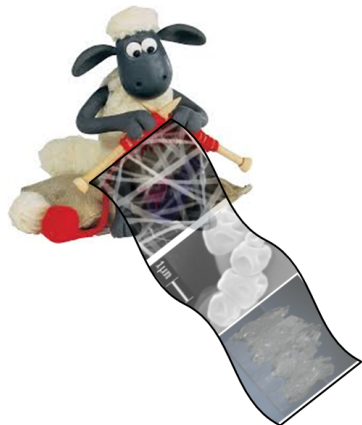
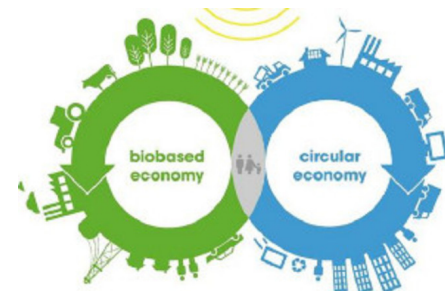



Attività pratica



An example of Circular Bioeconomy



The wool 
from a waste to a
resource

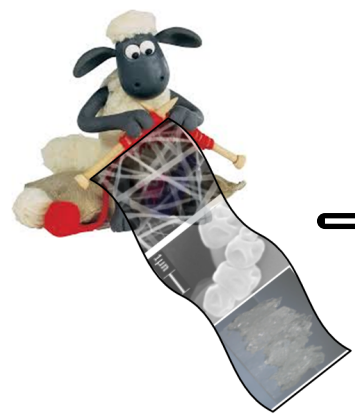


UrBIOfuture

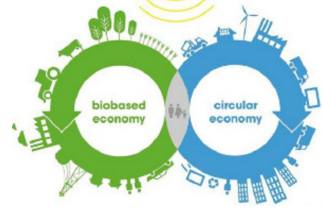
careers, education & research



Consiglio Nazionale
delle Ricerche



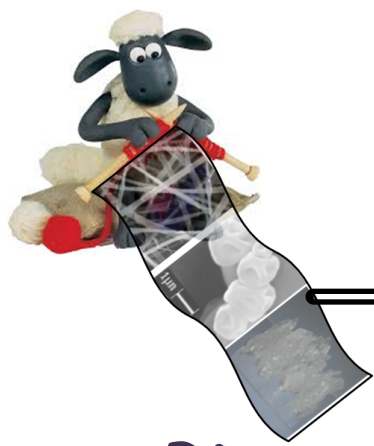
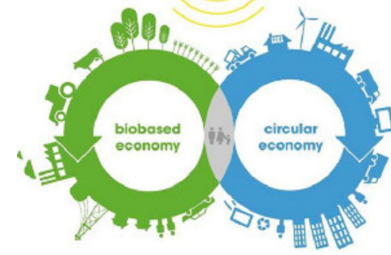
Learning Scenario



Aim & Methodology of the pathway

- **Combine the concepts of Circular Bioeconomy with the STEM disciplines** (Science, Technology, Engineering and mathematic).
- **Student Centred Learning:** the student is at the center of the learning process and he will work with minimal guidance and take initiatives.
- **Collaborative Learning:** group work promoted
- **Project-Based Learning:** the student is offered an activity based on identification and resolution of the problem.

Circular Bioeconomy concepts at the base of the course



Biomass

Wool wastes
From dairy sheep



Biorefinery

Keratin
Extraction



Processing

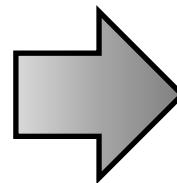
Final Product
(soap)

Value Chain

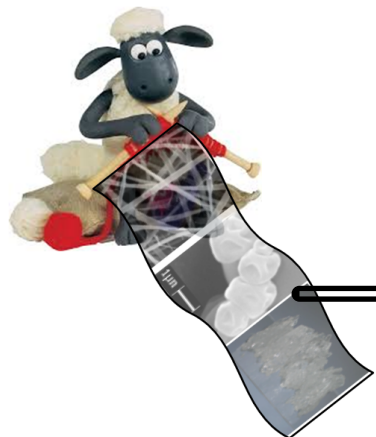
Cross-sector interconnection



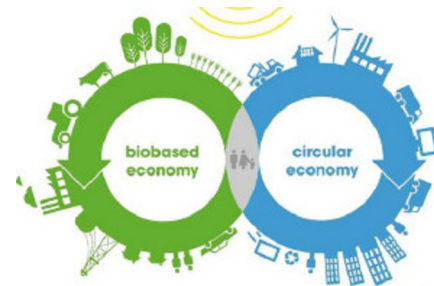
Agri-food sector



Cosmetic sector



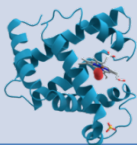
Connections with **STEM** disciplines



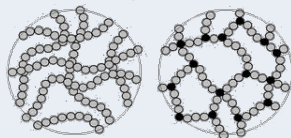
Biology – Chemistry - Technology



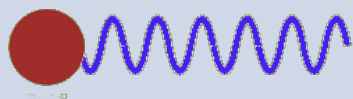
Acid-base reactions



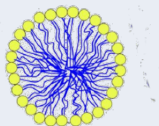
Proteins



Polimers



Saponification



Emulsifiers

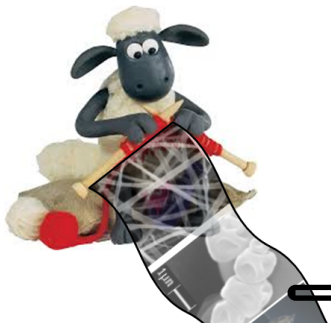


UrBIOfuture

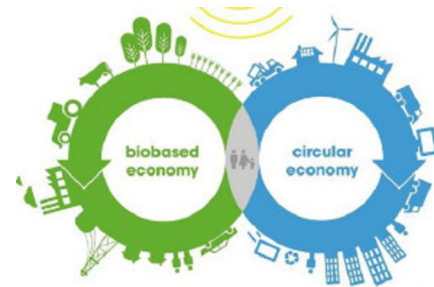
careers, education & research



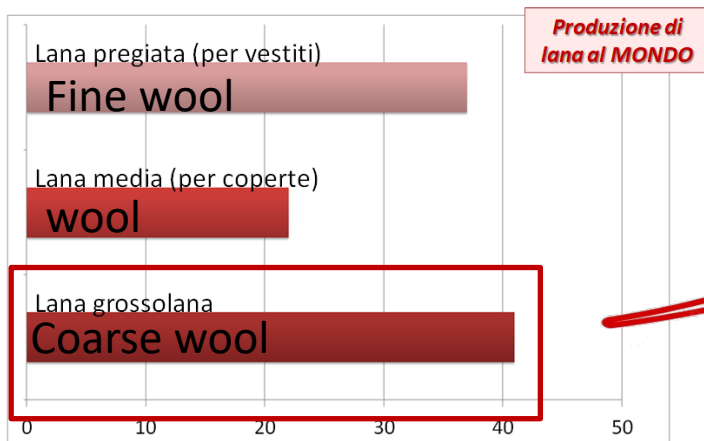
Consiglio Nazionale
delle Ricerche



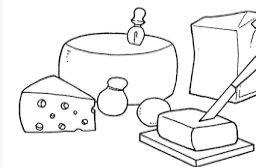
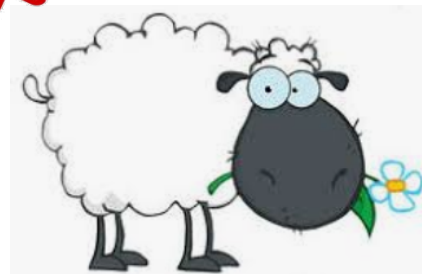
Introduction to the problem of wool wastes



International Wool Textile Organization (IWTO)




*EU -124 milioni di pecore/anno-
allevate per la produzione di
carne e latte*



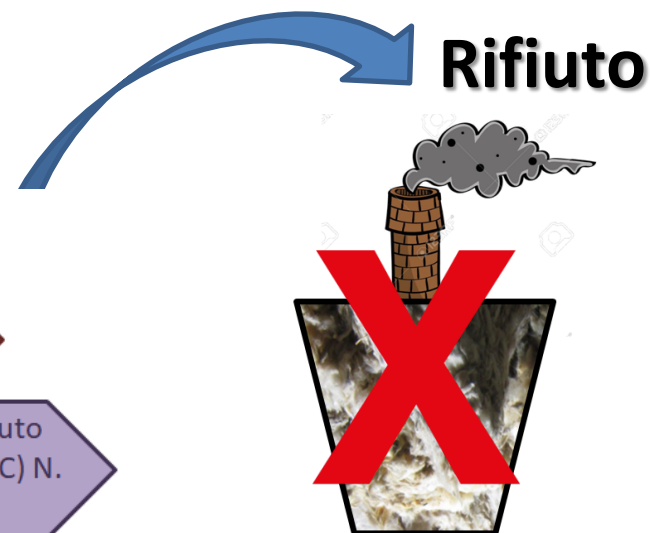
Italia



~7.000.000/anno pecore in Italia 

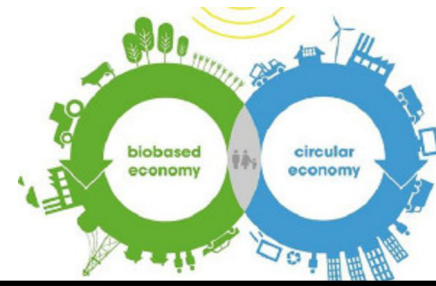
1,5 Kg lana/pecora → 10.500 tonnellate di lana 

La lana scarto è un RIFIUTO di categoria 3 che necessita di essere smaltito come rifiuto speciale (COMMISSION REGULATION (EU) N. 142/2011 implementing Regulation (EC) N. 1069/2009)





The chemistry of Wool



PROTEIN

KERATIN

AMINOACIDS

$$\begin{array}{c} \text{O} \\ \parallel \\ \text{HO}-\text{C}-\text{CH}_2-\text{NH}_2 \\ | \\ \text{R} \end{array} + \begin{array}{c} \text{O} \\ \parallel \\ \text{HO}-\text{C}-\text{CH}_2-\text{NH}_2 \\ | \\ \text{R} \end{array}$$

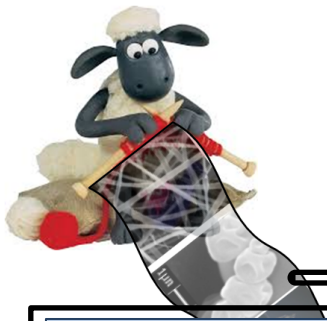
↓

$$\begin{array}{c} \text{O} \quad \text{R} \quad \text{H} \quad \text{O} \quad \text{R} \quad \text{H} \\ \parallel \quad | \quad | \quad \parallel \quad | \quad | \\ \text{HO}-\text{C}-\text{CH}_2-\text{N}-\text{C}-\text{CH}_2-\text{N}-\text{H} \\ | \quad \quad | \quad \quad | \quad \quad | \\ \text{H} \quad \quad \text{H} \quad \quad \text{H} \quad \quad \text{H} \end{array} + \text{H}_2\text{O}$$

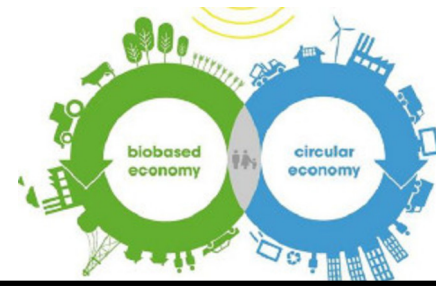
PEPTIDE BONDS

Diagram illustrating the structure of wool fibers, showing the progression from a **Helical Coil** to a **Twisted Molecular Chain**, then to **Microfibril**, **Macrofibril**, **Matrix**, **Cortical Cell**, and finally the **Cortex** and **Cuticle**.

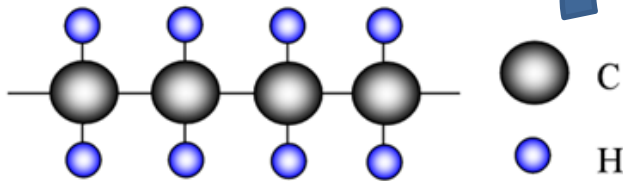
Skin – Hair - Nails



The chemistry of Keratin



POLIMER



Processing

Consumer Goods

Creams



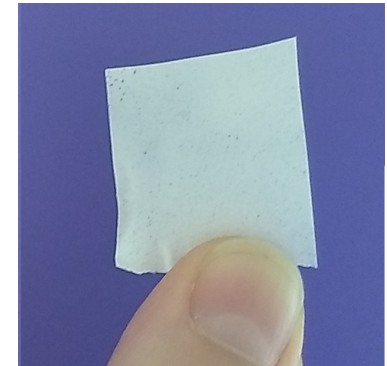
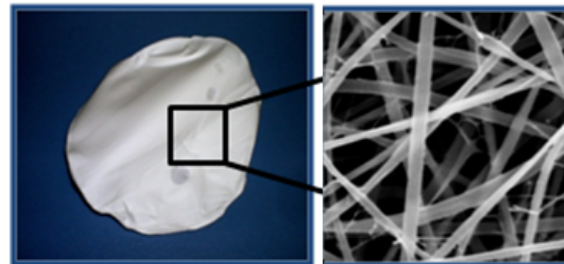
Lotions



Gels

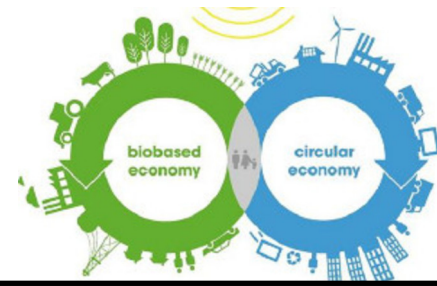


Nanofibers





The chemistry of Keratin

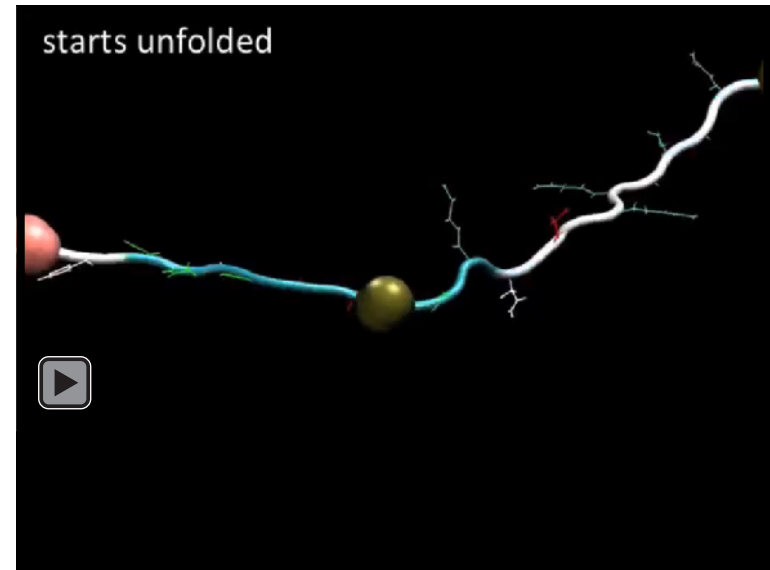
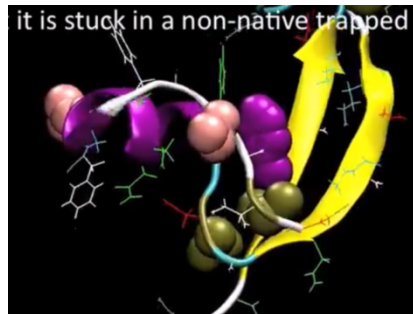


pH-sensitive

pH basico

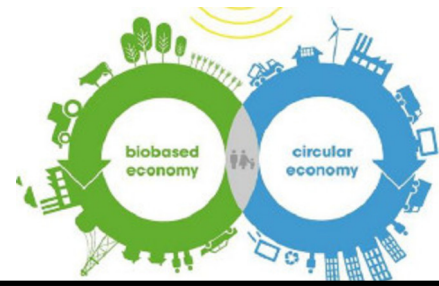


pH acido

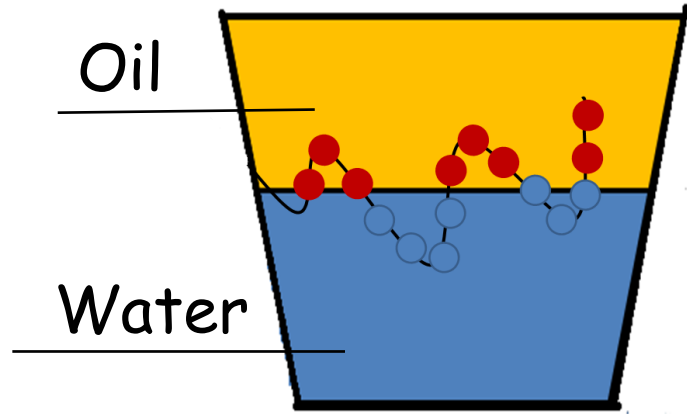
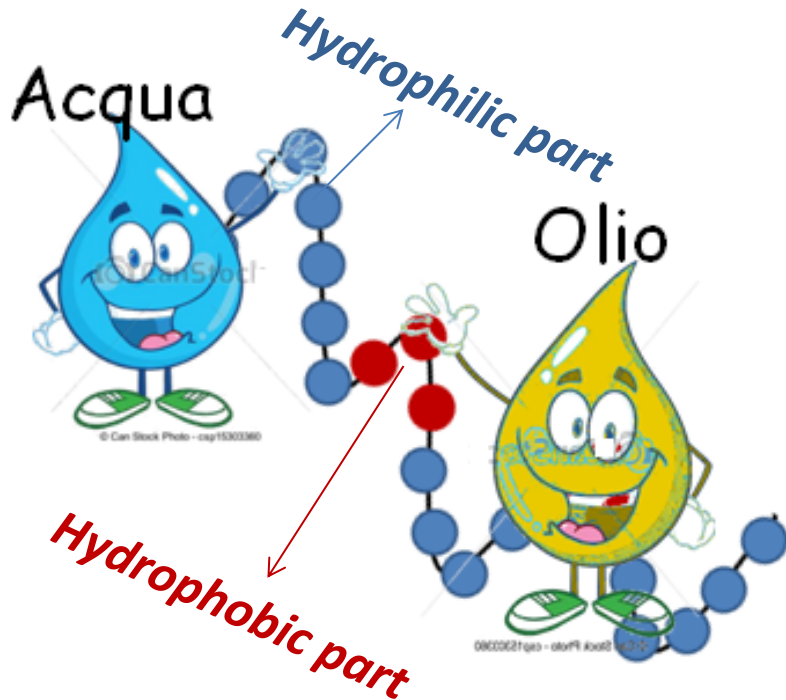




The chemistry of Keratin



Emulsifier



Emulsion

EXPERIMENT:

1. KERATIN EXTRACTION FROM WOOL



<https://rmschools.isof.cnr.it/moodle/>

| Materials | |
|----------------|------------------|
| Coarse Wool | Test tube |
| NaOH 1M | Test tube holder |
| Vinegar | Gloves & Glasses |
| Beker (200 mL) | Protective Coat |
| tweezers | colander |

EXPERIMENT:

1. KERATIN EXTRACTION FROM WOOL

Procedure: Dissolution Phase of Wool



Time

0h

2h

24h

EXPERIMENT:

1. KERATIN EXTRACTION FROM WOOL

Procedure: dissolution phase of wool

What happens?

1. KERATIN EXTRACTION FROM WOOL

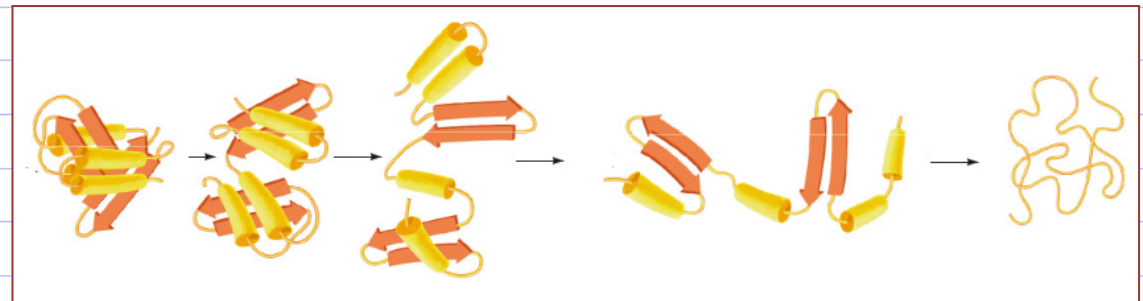
Procedure: dissolution phase of wool

Remarks

The wool fibers disintegrate and take on a gelatinous and dark appearance

Discussion

The NaOH solution has a basic pH, therefore keratin chains lose their 3D structure (denaturation), and the fibers dissolve making the solution gelatinous. The dark colour is caused by the degradation of some amino acids.



Proteina Nativa

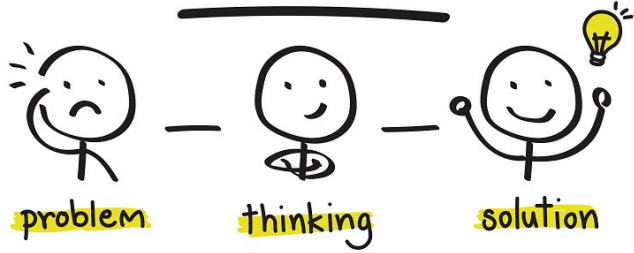


Proteina Denaturata

ESPERIMENTO:

1. ESTRAZIONE DELLA CHERATINA DALLA LANA

CRITICAL THINKING



How do we recover the dissolved protein?

ESPERIMENTO:

1. ESTRAZIONE DELLA CHERATINA DALLA LANA

Procedimento: Fase di flocculazione della cheratina



Cosa succede?

1. KERATIN EXTRACTION FROM WOOL

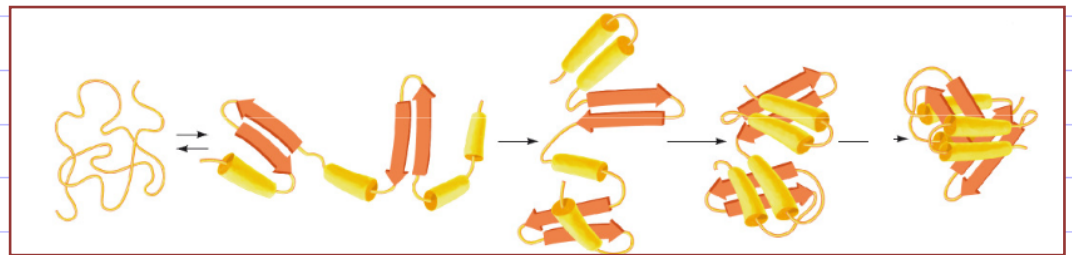
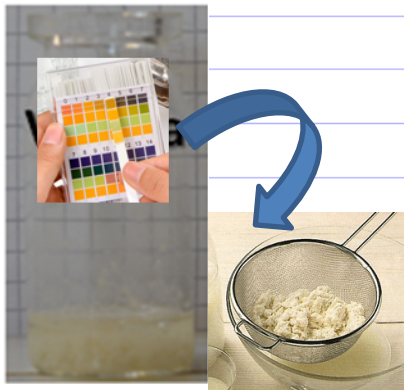
Procedure: flocculation phase of keratin

Remarks

Keratin flakes precipitate from the solution.

Discussion

This process occurs because in the acidic environment of acetic acid the protein chains reorganize into complex supermolecular structures. The protein therefore becomes insoluble and can be easily extracted by filtration on a strainer..



Unfolded protein



Folded protein

EXPERIMENT:

2. PROTEIN SOAP BASED ON KERATIN

Keratin powder



- Eco-friendly emulifier
(*substitute of synthetic emulsifier*)
- nourishing for the skin



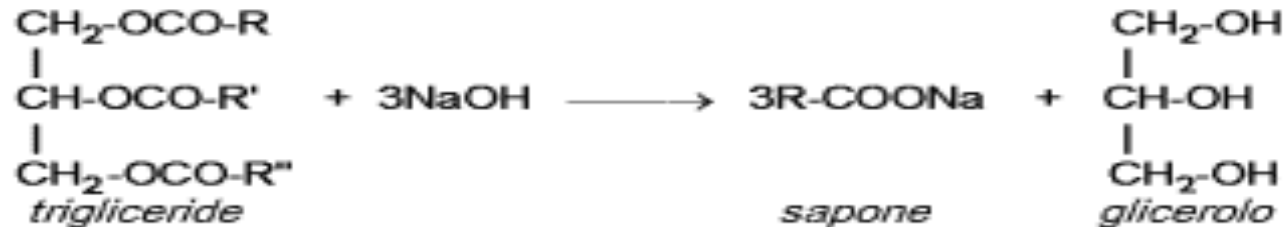
What is a soap?

Salt of a fatty acid, which is obtained by the basic hydrolysis reaction of a triglyceride (**fat phase**) by a strong base (**water phase**).

EXPERIMENT:

2. PROTEIN SOAP BASED ON KERATIN

Saponification reaction



Materials

- Becher 200 mL, flask 250 mL, heating plate, mixer, balance, spatula, molds, pipette, shaker, thermomether, graduate cylinder 100 mL;
- Keratin, NaOH pellets, almond oil, olive oil, distilled water;

EXPERIMENT:

2. PROTEIN SOAP BASED ON KERATIN

Procedure: **Preparation of fat phase**

- ✓ Weight 39 g of olive oil in a becher;
- ✓ Add 80 ml of almond oil;
- ✓ Heat to a temperature of 45°C



EXPERIMENT:

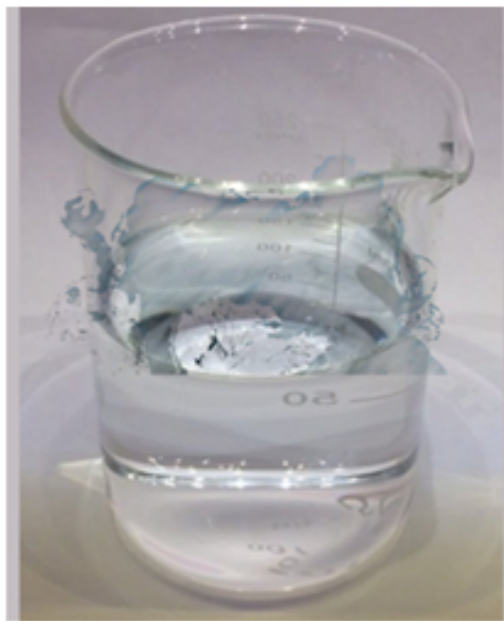
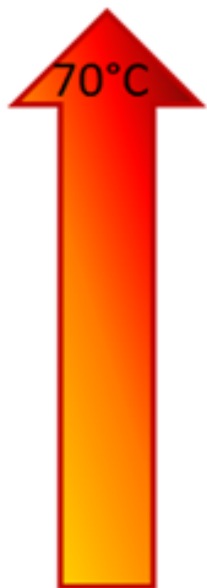
2. PROTEIN SOAP BASED ON KERATIN

Procedure: Preparation of fat phase

- ✓ Weight 34 g of NaOH in a becher;
- ✓ Dissolve it into 68 ml of distilled water.



Exothermic reaction



EXPERIMENT:

2. PROTEIN SOAP BASED ON KERATIN

Procedure: **Praparation of the trace**

- ✓ Mix the fat phase nad water phase with a shaker until reaching a trace;
- ✓ Add keratin (from 2 to 10g) and mix again
- ✓ Add some drops of lavender oil (or other ingredients).

Keratin



Emulsion



Lavender oil



EXPERIMENT:

2. PROTEIN SOAP BASED ON KERATIN

Procedure: Seasoning phase



Seasoning for 8 weeks



Soap



Liceo Galvani
Classe 3M (2017)
Prof. Faccenda

Liceo Sabin
Classe 3CSA (2018)
Prof. Vasile

Liceo Copernico
Classi 4P e 4F (2017-2018)
Prof. Merlo-Pich

Istituto di Istruzione
Superiore Majorana
Classe 3G (2019)
Prof. Caruso