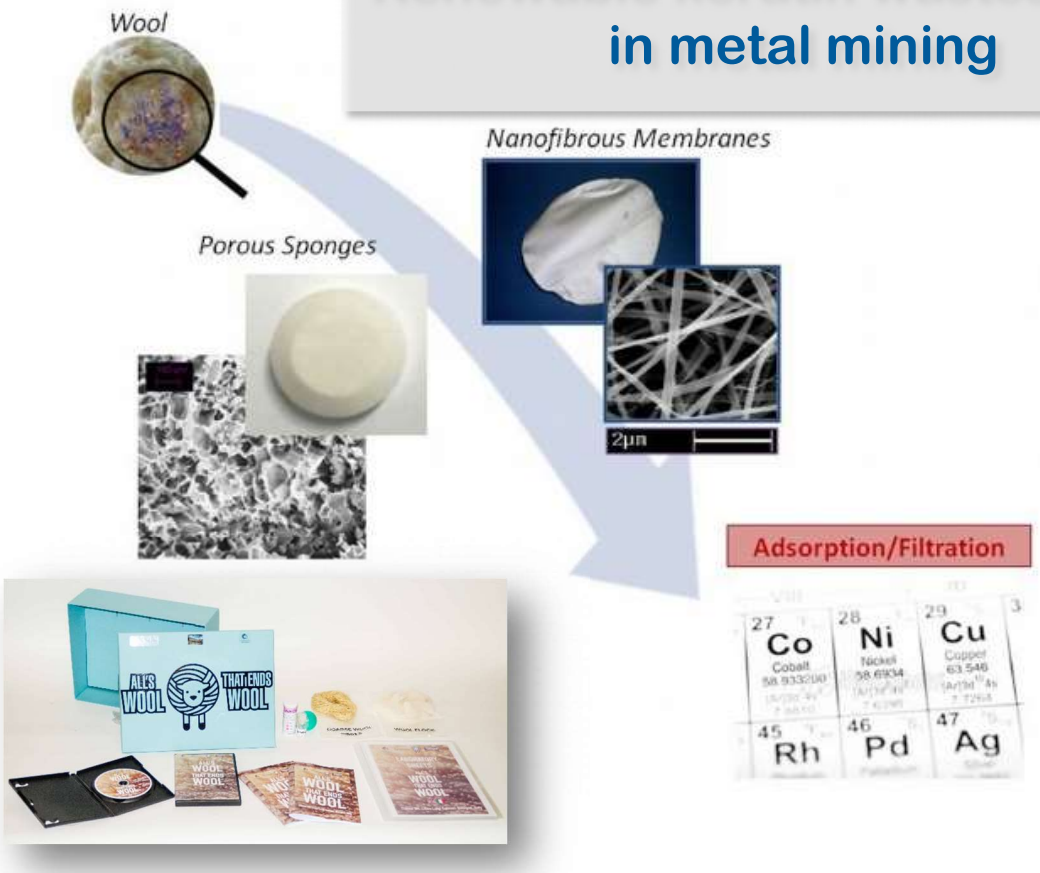
Teachers' Card

Renewable keratin wastes for use in metal mining



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General Introduction

Biopolymers from sustainable resources are being considered as alternatives to commodity synthetic polymers. Keratin from wool wastes can be used to prepare biodegradable new products for biomedical fields and filtration systems for water depuration and air cleaning.

The toolkit consists of laboratory activities relating to the extraction of keratin from wool waste, its identification and its use, supported by many tutorial videos and an in-depth dossier.

Key words: *Wool, Keratin, Circular Economy, Recovery*

Extended background information

Wool is the primary product of sheep farming. However, in recent years it has been facing a period of severe crisis mainly due to competition in the textile sector, the most profitable market for this type of fiber, and the farms pivoted to being mainly exploited for meat and milk.

Although over time the use of sheep has changed and their fleece is no longer exploited for the creation of high quality clothes, they still require shearing.

According to European legislation, wool must be considered as a special waste because, if polluted with dirt and humus, it can carry diseases and infections and it is no longer possible to abandon it in the pastures or let it slowly burn, with the consequent release in the atmosphere of toxic gases and carbon dioxide.

Insights on the topic in:

Appendix 1 – All's wool that ends wool

Glossary

- **Keratin**: it is a fibrous structural protein found in vertebrates
- **Polymer**: a macromolecule composed of many repeating subunits

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Key Competence European Framework

Literacy competence
S1. Ability to understand and interpret concepts, feelings, facts or opinions in oral and written form.
S2. Ability to express concepts, feelings, facts or opinion in written and oral form.
S3. Ability to interpret the world and relate to others.
S4. Ability to interact in an appropriate and creative way in any situation.
Multilingual competence
S1. Ability to understand and interpret concepts, feelings, facts or opinions in oral and written form.
S2. Ability to express concepts, feelings, facts or opinion in oral and written form.
S3. Ability to interpret the world and relate to others.
S4. Ability to interact in an appropriate and creative way in any situation.
S5. Knowledge of vocabulary, grammar and language.
S7. Ability to use technical language accordingly to the field of work.
Mathematical competence and competence in science, technology and engineering
S1. Ability to use constructed thinking in order to solve a problem in every situation.
S4. Readiness to address new problems from new areas.
S5. Capacity for quantitative thinking.
S6. Ability to extract qualitative information from quantitative data
S8. Ability to design experimental and observational studies and analyse data resulting from them.
Digital competence
S1. Critical use of information technology for work
S2. Basic skills in ICT
S4. Ability to use and handle technological tools and machines
Personal, social and learning to learn competence
S1. Ability to pursue and persist in different kinds of learning.
S2. Identifying available opportunities.
S3. Ability to gain process and assimilate new knowledge, skills and qualification required for career goals.
Citizen competence
S1. Ability to effective interaction with other people
S2. Ability to adapt to the changing situation, being flexible and work under pressure
S3. Ability to work effectively and collaborate with other team members
Cultural awareness and expression competence
S1. Ability to turn idea into action
S2. Creativity/innovation
S3. Ability to plan and manage tasks
S4. Independence, Motivation and Determination

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United Nations' Sustainable Development Goals

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.

	1 NO POVERTY, 2 ZERO HUNGER — Enable access to basic services		10 REDUCED INEQUALITIES — Equal access to global expertise
	3 GOOD HEALTH AND WELL-BEING — Safe medical devices		11 SUSTAINABLE CITIES AND COMMUNITIES — Sustainable urbanization
	4 QUALITY EDUCATION — Access to education	✓	12 RESPONSIBLE CONSUMPTION AND PRODUCTION — Responsible consumption and production
	5 GENDER EQUALITY — Less hardship, more opportunities	✓	13 CLIMATE ACTION — Strengthen resilience, reduce disaster impact
✓	6 CLEAN WATER AND SANITATION — Safe and affordable water		14 LIFE BELOW WATER — Reduce marine pollution
	7 AFFORDABLE AND CLEAN ENERGY — Energy – the golden thread		15 LIFE ON LAND — Sustainable use of terrestrial ecosystems
✓	8 DECENT WORK AND ECONOMIC GROWTH — Safety of workers and economic growth		16 PEACE, JUSTICE AND STRONG INSTITUTIONS — Promote peaceful and inclusive societies
	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE — Resilient infrastructure and sustainable industrialization		17 PARTNERSHIPS FOR THE GOALS — Better access to technology and innovation

Contents – Theoretical principles

Thanks to the use of new technologies, raw wool or recycled wool today can be used in the agricultural sector as a nitrogenous fertiliser or in construction industry because of its properties; in fact, it is a good insulating material, it is long-lasting, fireproof and highly transpiring.
it has been discovered that wool could be used to clean up soils contaminated by heavy metals and to purify water from hydrocarbons.

RawMaterials
EIT RawMaterials is supported by the EIT, a body of the European Union

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Wool contains about 85% of keratins, a family of fibrous proteins, insoluble in water and in solutions slightly acidic or basic, resistant to proteases. Its chemical composition has a high content of an amino acid sulphide, cysteine.

Keratin is extracted by breaking the bonds of disulphide through the action of reducing or oxidizing agents; in our toolkit after the extraction we flocculate the protein that is in the solution and finally, through the processes of decantation and drying, it becomes possible to see the keratin powder.

Nanofibers based on keratin could help in tissue engineering to produce scaffolds, which are supports for the cellular growth, in particular for the proliferation of fibroblasts, typical cells of the connective tissues.

Lab Procedure/Activity

The toolkit consists of five modules associated with laboratory experiences regarding the extraction, flocculation and identification of keratin and its ability to absorb heavy metals.

Each experience is associated with a video that describes it, and a student's card that can be printed and given to students.

A dossier contains information regarding the history, characteristics and use of wool.

List of Modules associated to this activity (corresponding to Student's card 1-5)

Module 1 – Keratin extraction from wool

Module 2 – Wool keratin flocculation and precipitation

Module 3 – Keratin identification

Module 4 – Wool absorption of heavy metals

Module 5 – Keratin container for plants

List of Tutorial Videos associated to this activity

Video 1 – Keratin extraction from wool

Video 2 – Wool keratin flocculation and precipitation

Video 3 – Keratin identification

Video 4 – Wool absorption of heavy metals

Video 5 – Keratin container for plants

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Dossier

Appendix 1 – All's wool that ends wool

Test

Appendix 2 – Crossword

Appendix 3 – Crossword solution

Appendix 4 – Student's test

Appendix 5 – Student's test solution

Learning Pathway

The proposed didactic path can be used as an extracurricular in-depth study or can be inserted in the syllabus of a biology or chemistry course in which biomolecules, in particular proteins, are studied.

The execution of all the various activities is divided into 10 steps, but it is possible to reduce them by combining the second part of an experience with that of preparing a subsequent one.

We have not listed the in-depth activities relating to wool, its recycling and the use of keratin that we think can be assigned individually to the various groups, which should then present them to their classmates at a later date.

The crossword (Appendix 2) can be used at the end of the entire educational path.

Step 1- Time & Activity:

- 30 minutes: teacher introduction
- 15 minutes: Module 1 (Keratin extraction from wool - first part) - Students are divided into groups (the preferable number of students for each group is 3-4). Each group proceeds with the extraction.

Step 2 – Time & Activity:

- 30 minutes: Each group observes the results obtained, completes the table in Module 1, answers to the questions. Subsequently, the teacher coordinates the discussion between the various groups.
- 15 minutes: The teacher assigns to each group an in-depth topic, in the form of a presentation, and defines the times and the calendar according to which each group will report to the rest of the class

about it. For further information, Appendix 1 may be used, possibly integrated by students, or leave freedom of documentation to the students.

Step 3 – Time & Activity:

- 30 minutes: The students, divided into groups, carry out the first part of Module 2 (Keratin flocculation), using the extraction solution of Module 1. They complete the table and answer to the questions. For the drying it is necessary to wait a few days, therefore the observation of the dried samples will be carried out later (it will take about 5 minutes).
- 10 minutes: the teacher coordinates the discussion between the various groups.

Step 4 – Time & Activity:

- 30 minutes: The students, divided into groups, carry out Module 3 (Keratin identification). They also complete the table and answer to the questions. Knowledge of amino acids, peptide bonds, proteins and their structure are an indispensable prerequisite for being able to adequately answer to questions.
- 10 minutes: the teacher coordinates the discussion between the various groups.

Step 5 – Time & Activity:

- 15 minutes: The students, divided into groups, carry out the first part of Module 4 (Wool absorption of heavy metals).

Step 6 – Time& Activity:

- 20 minutes: The following day, the groups complete the experience, they write the results in the table and answer the questions.
- 10 minutes: the teacher coordinates the discussion between the various groups.

Step 7 – Time & Activity:

- The experience described in module 5 (Keratin container for plants) requires very long waiting times; the preparatory phase (Keratin extraction) can be carried out previously: for example, by calculating a greater quantity of reagents in step 1.
- 10 minutes: preparation of the small plant pot.

Step 8 – Time & Activity:

- 10 minutes: The next day the groups wash the small plant pot.

Step 9 – Time& Activity:

- 20 minutes: After 1 or 2 weeks, the groups complete the experience, they write the results in the table and answer to the questions.
- 10 minutes: the teacher coordinates the discussion between the various groups.

Evaluation

Test

Appendix 2 – Crossword that can be used as a formative assessment

Appendix 3 – Crossword solution

Appendix 4 – Student's test to be used as a summative assessment

Appendix 5 – Student's test solution

We think that an in-depth presentations assigned to various groups in the class can also be a valid evaluation tool.

Description of Student's Cards

List of Students' Cards associated to this toolkit.

Student's Card 1 – Keratin extraction from wool

Student's Card 2 – Wool keratin flocculation and precipitation

Student's Card 3 – Keratin identification

Student's Card 4 – Wool absorption of heavy metals

Student's Card 5 – Keratin container for plants

RawMaterials
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Dossier

Appendix 1 – All's wool that ends wool

Sources

Further details can be found by consulting the bibliography in the appendix to the file "Appendix 1 - All's wool that ends wool".
Here are reported only some references regarding the **wool utilizations**

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