SCIENTIFIC, TECHNICAL AND VOCATIONAL EDUCATION OF GIRLS IN AFRICA

Science Experiments

by

Julie Ladel and Jerôme Thibault

Section for Science and Technology Education
Section for Technical and Vocational Education
Working document 1999

ED-99/WS/36

Contact:

Anna Maria Hoffmann-Barthes
Programme Specialist
Section for Science and Technology Education
UNESCO
7, place de Fontenoy
F-75352 Paris 07SP
Fax. +33-145685622
Email AM.BARTHES@UNESCO.ORG

CONTENTS

PREFACE

UNESCO's current Medium-Term Strategy (1996-2001) designated Women and Africa as priority target groups for action. In this context, a six-year ***Special Project on Scientific, Technical and Vocational Education of Girls in Africa*** was launched in 1996 with the aim to reduce gender disparities in this field. This is a joint project of the Section for Science and Technology Education and the Section for Technical and Vocational Education, undertaken in close co-operation with international, regional and national governmental and non-governmental organizations.

The overall objectives of the project are:

1. To improve the access of girls to scientific, technical and vocational education (STVE);
2. To break the barriers for girls in secondary school, notably by improving the quality and effectiveness of STVE;
3. To make an impact on the attitudes and stereotypes of teachers, which prevent girls from taking advantage of current opportunities in science and technology;
4. To promote a positive image of women in scientific and technical careers;
5. To sensitize policy makers, parents, employers and the general public about the ways in which women's full participation in science and technology can make a positive difference for current and future generations.

The present document specifically covers science education, and attempts to provide examples of science experiments specially prepared and selected to raise the interest of girls towards sciences and in the long-term motivate them towards science and technology education and related careers.

The key-place of science and technology in our society today requires **scientific and technological literacy for all**. Science and technology education activities should thus give the opportunity for all - children, teenagers and adults, male and female - to discover or revise basic notions which enable a better understanding of the world. However, the content of, and examples and illustrations in many science-related curricula and other educational materials tend to build more on the experiences of boys and ignore those of the girls.

The concepts and principles of science and technology education are universal, however, the way they are presented and illustrated should be put into a gender-sensitive and cultural context to facilitate understanding and teaching from the known to the unknown for all, both girls and boys.

While a lot of science and technology (S&T) is encountered in the home, and particularly in the kitchen, this fact is hardly ever used to introduce concepts/topics such as Heat and Temperature, Solubility and Solutions, Prevention of Rusting, Food Preservation as well as Waste Management and Disposal. Similarly, a lot of technology at the basic level can be taught starting from activities and experiences of girls, in addition to those of boys. For example the concept of appropriate technology can be taught using examples of labour-saving and timesaving devices that are of direct assistance and hence interest to girls like energy-conserving stoves, water pumps and heaters.

This document proposes experimental scientific and technological low-cost activities on topical issues related to daily life, that can be adapted by educators to the local context or enriched with activities based on their own experience. Guidelines can be found in the following chapter to help in their implementation and development.

Most of these activities have been elaborated from the work and experience of the Association "Graine de Chimiste" from the University of Paris (France). In France, Belgium and Portugal, this Association has introduced more than 50,000 people, children from 5 years and above, teenagers and adults, in formal and non formal contexts, to hands-on experiments, giving gestural and scientific knowledge and skills.

In the medium-term, the objective is to enrich this document in order to publish a more complete resource kit on gender sensitive science activities. Experiments that you would like to add can be submitted to:

Section for Science and Technology Education (ED/SVE/STE)
UNESCO
7, place Fontenoy
75352 Paris 07 SP
France

GUIDELINES

Presentation of the activities

The activities, presented in reproducible sheets, can be implemented in formal and non-formal contexts with participants from 10 to 16 years old. Most of the activity sheets can also be adapted for a younger public target, from 5 years and above.

All activity sheets are presented with the same format, comprising:

- the **activity title**, its **duration**, its individual or group **implementation**
- a detailed **experimental protocol** to implement the activity (required products and materials list, possible special care to be taken, operating procedure to be scrupulously followed)
- a **synthesis of observations**
- **remarks** about important notions or to widen the activity field

Activities are divided in five parts which can be dealt with separately and adapted to the participants level and to material conditions:

- 5 activities (L1 to L5) to show that "**Washing with water**",
- 3 activities (C1 to C4) to "**Making cosmetics**",
- 6 activities (S1 to S6) to "**Learning with a soap film**",
- 3 activities (E1 to E3) to "**Using renewable energies**",
- 3 activities (M1 to M5) to "**Making or recycle materials**".

Certain activities are more adapted for group implementation and others for individual implementation. For each activity, "duration" and "individual" or "in group" notes will enable the educator to organize the sessions.

Sequencing within a theme

The sequencing proposed for each of the five parts is due to a progression in transdisciplinary scientific notions tackled or to an approach based on daily life to explain more complex phenomena. In an educational perspective, the session can be re-organized depending on the educator's objectives.

Objectives of the activities proposed

All activities are proposed for individual implementation by the participants, under the supervision of the educator, who will organize the exchange of results, theoretical and practical inputs and animate the discussions.

Undertaking the activities with respect to hygiene and security and with a "scientific protocol" (the activity sheets) help to create a rigorous and confident climate required for scientific experimentation.

The educator could also support initiatives of the participants to develop activities themselves and induce the writing of experimental protocols on topics close to participants, before implementation and discussion on the experiment (security, operating difficulties, theoretical difficulties, etc.).

Depending on the educational objectives, the activities evaluation should consider either manipulative skills, conceptual or methodological acquirements.

Guidelines for the development of new activities

A complete science and technology education can not only consist in transmitting information and existing solutions only, but should lead to the acquirement of values, knowledge and skills, and a also critical mind, all of which is useful in daily life.

The most pertinent activities deal with the participants' affective environment and enable them to perceive the world differently. Concepts and principles, experimental methods and technology mastery are only tools that contribute to the understanding of natural phenomenon, general or topical processes and usual practices.

Examples of activities topics are among others the universe and natural laws perception, the environment in its globality, the living organisms behavior and their belongingness to ecosystems, health, the infinitely little discovery, the processes involved in cooking, washing, do-it-yourself, genetics, bionic, mechanics, renewable energies, materials knowledge, new technologies.

Activities' preparation by the educator

The pre-implementation of each experimental activity is highly recommended, to enable the educator to anticipate the material difficulties,

find solutions to the problems faced and to prepare the organization and the development of the session.

For indication, the preparation comprises the following steps:

- **activity material adaptation** by the educator (supply of material and products depending on local conditions); if possible, as any participant implement the activity individually, material and products should be planned for all.
- **implementation** of the **activity** by the educator
- **information search** for the educator to anticipate questions or difficulties to be explained to participants
- **talk preparation and activity organization** (including experimental, discussion and thought periods)
- **activity developments preparation** (preparation of an exhibition or a survey, industrial site visit, article writing, professionals meeting, etc.)

For hygiene, security and pedagogy reasons, any participant shall:

- dispose of his/her own **material** and **products**
- wear **clean cotton clothes** reserved for experimentation
- wash his/her **hands** before and after hands-on activities
- tie **long hair**
- wear **gloves** and **goggles** for activity M2 which requires products.

The respect of these few precautions will guarantee a good progress of experimental activities.

Preliminary adaptation of material

The handled material is obtained, as possible, from daily life objects with minimum risk and adapted (wood or plastic objects instead of glass). The following, in bold, are the materials mentioned in the activity-sheets experimental protocols, which can be replaced, if necessary, by the materials in brackets:

- **a box** (in plastic, in cardboard)
- **a car headlight reflector**
- **a clothes line, clothes pins**
- **a filter (**a paper filter at the funnel's size, a absorbent cotton make-up remover ring, a bit of absorbent cotton to block a funnel)
- **a flask** (a dropper sold in pharmacies, or a vessel or yoghourt pot together with a non-graduated pipette or a straw only to be used with the finger and not with the mouth)
- **a funnel (**a plastic funnel, a box with smaller holes than the filter, the neck of a water bottle)
- **glass tubes**
- **a grille** (a device made of wire netting, an oven grille)
- **a measure** (a milk or coffee measure, a teaspoon, a soup-spoon - previously standardized with the solid to be withdrawn)
- **a measuring cylinder** (a plastic measuring cylinder, a known volume vessel consisting of a little water bottle, a tube or other vessel standardized before with a know volume of water)
- **a mirror** (a pocket mirror, light reflecting surface)
- **paper hankies:** cotton piece of rag
- **old papers**
- **a plastic foil:** a stretchable food film, a plastic bag
- **a plastic tube**
- **a piece of plate glass**
- **a pot** (a cleaned yoghourt vessel, a water bottle bottom or a glass vessel, a photographic film packaging)
- **a roller (**a rolling pin, a bottle)
- **screws, washers**
- **a spatula** (a spatula sold in pharmacies, a spoon or its handle, a cleaned ice cream stick)
- **a stick** (a toothpick, a skewer pick)
- **a stopper** (a cork, a water bottle stopper)
- **a stove** (a hotplate)
- **a tank, a cup, a plate** (half a Petri dish, a heatproof dish or plate (Pyrex))
- **an alcohol thermometer** (a mercury thermometer – remembering that mercury is toxic)

- **a thin tissue** (cotton or muslin fabric)
- **a trapeze** (a device made of soldered metallic rods and sewing thread)
- **a wash-bottle** (a plastic wash-bottle, a plugged water bottle)
- **a wooden board, wood tassels**

Preliminary adaptation and product storage

All products should be packaged in plugged flasks labeled with the product's name. For hygiene and/or security, never touch, smell nor taste a product (except for particular cases like tasting drinking waters). Most products required for the proposed activities are usual products. Solid ones are bottled in broad plugged flasks and liquid ones in plugged dropper-flasks or bottles to take them easily and safely.

The following products can be found in alimentary shops:

- water (tap water) — stored in a wash-bottle
- demineralized water (water for batteries) — stored in a wash-bottle
- salt, pepper, colorant — stored in vessels
- oil, aroma, perfume, milk, lemon juice, vinegar — stored in a flask
- ice — stored in a tank

The following products can be found in do-it-yourself shops:

- Liquid detergent (liquid soap) — stored in a flask
- Black paint
- glue
- MDI : 4-4' diphenylmethane diisocyanate — stored in its packaging
- polyol and expansion agent mixture — stored in its packaging

The following products can be found at pharmacies or laboratory suppliers:

- Liquids stored in flacon: isopropyle myristate, glycerin, ethanol, fluoride de sodium (40g.l-1 solution), sodium hydroxide(10 cm3 of solution 3 mol.l-1) sodium chloride (for the soap : saturated salt solution in demineralized water), formaldehyde, concentrated hydrochloric acid.
- Solids stored in pots: bees wax, lanolin, talc, preservative (propyle parahydroxybenzoate, facultative), cellulose, silica gel, sodium dodecyle sulfate, urea, polyvinylic alcohol (PVA).

Washing with water

W1. does water wet well ? (duration: about 15 minutes - individual)

products

- water
- liquid detergent

material

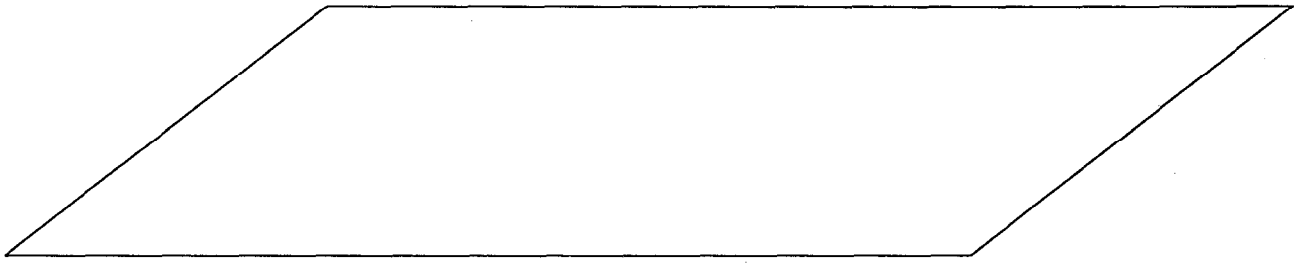
- 1 plastic foil or 1 piece of dry tissue

operating procedure

1. lay 2 distant water drops down the selected support
2. observe water drop s form
3. add 5 water drop s to form a big one
4. add 4 water drop s and 1 drop of liquid detergent
5. observe

observations

- Draw what you have obtained at the end of the experiment.



- Try to wet your hand wit ha few water drops. What do you observe?

.....

remarks

- Cross what is wrong:

  (The wetting power of a liquid is its ability to wet a surface.)

  Water has a good/bad wetting power.

  A detergent increase/decrease water wetting power.

- What is a detergent?

  .....

- Which detergents do you know?

  .....

- Which detergents do you use at home?

  .....

- Why do you use detergents?

  .....

Washing with water

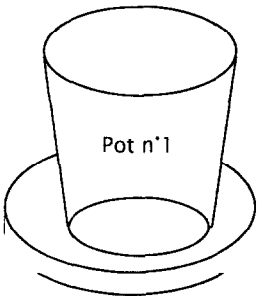
W2. Does water have a "skin"? (duration: about 15 minutes - individual)

products
- water
- liquid detergent

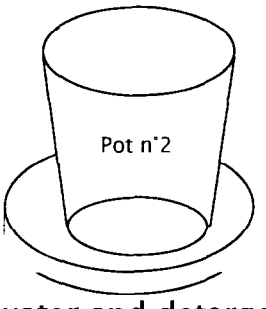
material
- 2 pots
- 2 cups

operating procedure
1- fill to the brim 2 pots placed on a cup with water
2- add in each pot 40 additional water drop s to form a meniscus
3- add 1 additional water drop in pot n°1
4- add 1 drop of liquid detergent in pot n°2
5- observe

observations
- Draw what you have obtained at the end of the experiment.



water

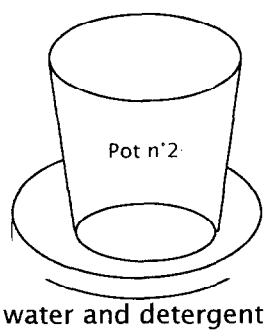


water and detergent

- What happened in the drink of water?.....
.....
- What happened in the drink of water to which detergent has been added? .....
.....

Remarks

- Water seems maintained by a stretched "skin" which prevent its overflow from the pot. It is under a surface tension, that is a force which pulls its surface to the inside: water is encountered by water avoiding as possible contact with air.
- Cross what is wrong off: A detergent increase/decrease water surface tension as water surface has increased/decreased and so its elasticity.
- Water is the liquid with the highest surface tension, except liquid metals such as mercury.
- A detergent is called surface-active as it changes liquids surface tension.
- Surface-actives chemicals such as detergents (schematized by ▒▒)are made of one part that likes water (or hydrophilic ▒) and another one that shuns water (or hydrophobic▒▒). They enable by this way the association of hydrophobic chemicals to water. Draw how will the detergent be placed at the water surface and in contact with the air, using graphical standards defined above.



water and detergent

Water is not sufficient to wash

W3. Water mixes to certain products (duration: about 45 minutes - individual)

products

- water
- oil
- coloring
- salt
- pepper (or talc)

material

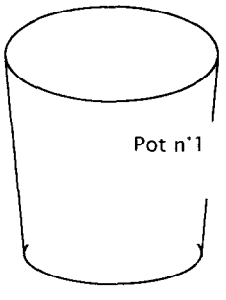
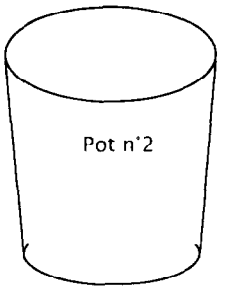
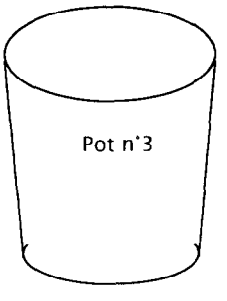
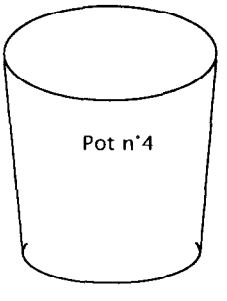
- 4 pots
- 4 spatulas
- 2 measuring cylinders of 10 cm^3
- 1 measuring cylinder of 50 cm^3
- 2 measures (equivalent to 3g of each solid)

operating procedure

1. take 10 cm^3 oil with a 10 cm^3 measuring cylinder
2. pour oil in a clean pot
3. take 50 cm^3 water with a 50 cm^3 measuring cylinder
4. pour water in the pot
5. mix with spatula and observe
6. do this experiment again with 10 cm^3 coloring and clean material
7. add 1 skimmed measure of salt in a clean pot
8. take 50 cm^3 water with a 50 cm^3 measuring cylinder
9. pour water in the pot
10. mix with spatula and observe
11. do this experiment again with 1 skimmed measure of pepper and clean material

observations

- When products that form a mixture can not be distinguished, the mixture is homogeneous.
  When products that form a mixture can be distinguished, the mixture is heterogeneous.
- Two liquids that form a homogeneous mixture are miscible.
  Two liquids that form a heterogeneous mixture are non miscible.
- A solid that forms a homogeneous mixture with a liquid is soluble in this liquid.
  A solid that forms a heterogeneous mixture with a liquid is insoluble in this liquid.
- Draw what you observes in each pot after mixture and cross what is wrong:

Mixture:	water and oil	water and coloring	water and salt	water and pepper
				
this mixture is	homogeneous heterogeneous	homogeneous heterogeneous	homogeneous heterogeneous	homogeneous heterogeneous
	oil is :	**the coloring** is :	**the salt** is :	**the pepper** is :
	miscible to water non miscible soluble in water insoluble in water	miscible to water non miscible soluble in water insoluble in water	miscible to water non miscible soluble in water insoluble in water	miscible to water non miscible soluble in water insoluble in water

remarks

- Water (natural, demineralized, distilled) is not a pure corps: on contact with the atmosphere, water dissolves existing gases (diazote, dioxygene, carbone dioxyde, etc.). By rocks dissolution, it may also carry various mineral substances (calcium carbonate (limestone), calcium sulfate (gypsum)). One can not talk about pure water.
- Water pollution results from the introduction of substances that were either absent (synthetic products), or present in lower quantities (nitrates, phosphates, etc.) in natural waters.

Water is not sufficient to wash

W4. Interest of detergents

(duration: about 30 minutes - individual)

products

- water
- liquid detergent
- oil
- pepper (or talc)

material

- 4 pots
- 1 measuring cylinder of 10 cm^3
- 1 measuring cylinder of 20 cm^3
- 5 spatulas
- 2 dropper-flasks

operating procedure

<u>non miscible liquids dispersion in water</u>

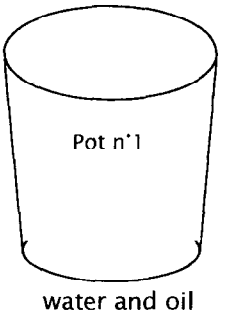
1- measure 20 cm^3 of water with a measuring cylinder
2- pour into pot n°1
3- measure 10 cm^3 of oil with a clean measuring cylinder
4- pour into pot n°1 and observe
5- prepare as above another mixture in pot n°2
6- add 20 water drop s in pot n°1
7- mix with a spatula the content of pot n°1 and observe
8- add 20 drops of liquid detergent in pot n°2
9- mix with a spatula the content of pot n°2 and observe

<u>insoluble solids dispersion in water</u>

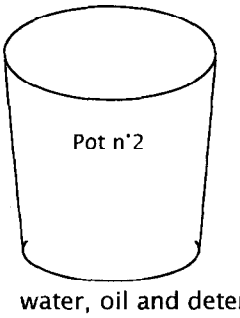
10- fill pots n°3 and 4 with water
11- add 1 hint of spatula of pepper in each pot
12- observe
13- add 1 water drop in pot n°3
14- mix with a spatula the content of pot n°3 and observe
15- add 1 drop of liquid detergent in pot n°4
16- mix with a spatula the content of pot n°4 and observe

observations

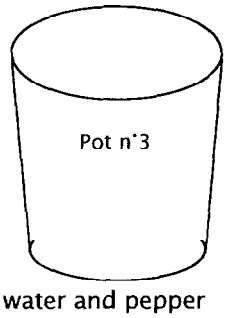
- Draw what you observe at the end of the experiment.



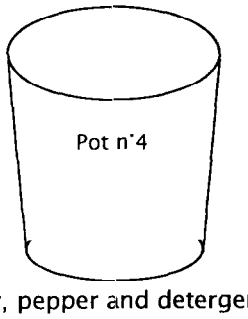
water and oil



water, oil and detergent



water and pepper



water, pepper and detergent

remarks

- What is the detergent role in this experiment?

.....

- Insoluble or non miscible products dispersion in water is increased when clothes are beaten.
- Indicate your colors(▭) and schematize how you imagine products in relation to the others within the mixture:

water ▭
detergent ▭
oil ▭
pepper ▭

water, oil and detergent

water, pepper and detergent

Washing with water

W5. Clothes washing

(duration: about 30 minutes - individual and in group)

questionnaire

- Clothes can be dirtied by several kinds of dirt.
  Indicate examples of dirt: .....

- Indicate, for each example, dirt properties (solid/liquid ; soluble/insoluble in water or miscible/non miscible with water ; hydrophilic/hydrophobic):
  - sugar: .....
  - dust (see experiment with pepper): .....
  - blood: .....
  - salt: .....
  - oil (or other fats): .....
  - coloring: .....

- During washing, soluble and insoluble products in water, miscible and non miscible to water are eliminated. Indicate the case(s) where the use of detergent is <u>necessary</u>.
  - a product soluble in water is eliminated with/without detergent (example : .....)
  - a product insoluble in water is eliminated with/without detergent (example : .....)
  - a product miscible to water is eliminated with/without detergent (example : .....)
  - a product non miscible to water is eliminated with/without detergent (example : .....)

- Cloth washing is decomposed of five steps (rinse, wet, wringing, washing in itself (use of detergent), beating). Indicate the washing steps name in chronological order:
  - first step : .....
  - second step : .....
  - third step : .....
  - forth step : .....
  - fifth step : .....

remarks

- **Blood** is a red liquid composed of plasma and corps in suspension in plasma (red corpuscles, white corpuscles, plaques). Plasma carries lots of dissolved substances such as mineral salts, proteins (e.g. albumin), lipids (or "fats"), sugars and wastes from living organisms functioning.

- Substances such as blood which contain **proteins**, organic substances present in any living bodies, are heavy and difficult to carry by detergents. Modern washing powders comprise **enzymes**, biological substances of protein nature, with the characteristic to decompose certain proteins in smaller pieces. These pieces are thereafter easier to be eliminated by detergents.

Making cosmetics

C1. Make-up preparation

(duration: about 1 hour - individual)

products

- bees wax
- lanolin
- talc
- preservative facultative)
- coloring (facultative)

material

- 1 tank for boiling water
- 1 stove
- 2 spatulas
- 1 pot
- 1 soup-spoon (lanolin)
- 1 stopped flask
- 1 label sticker

operating procedure

1. **prepare** boiling water by heating water in a resistant tank placed on a stove
2. **switch** the stove **on**
3. **put** with a spatula 12 grains of bees wax in a pot
4. **skim** 1 tablespoonful of lanolin with a clean spatula
5. **place** the soup-spoon in the pot
6. **place** the pot in the boiling water
7. **wait** till the pot content has completely melt
8. **remove** the pot from the boiling water
9. **add** 1 hint of spatula of preservative (facultative)
10. **add** 2 skimmed measures of talc with the clean spatula
11. **mix**
12. **add** 40 drops of coloring (facultative)
13. **place** the pot in boiling water again (about 1 minute)
14. **remove** the pot from boiling water
15. **switch** the stove **off**
16. **mix** the pot content
17. **for into** the pot content in a flask
18. **block and label** this flask

remarks

- Cosmetics are non medicinal substances or preparations aimed at body care, wash, beauty. They are on contact with teeth, mucous and other external parts of the body. They are used to wash (detergents), protect, maintain in fit state, modify the aspect, perfume, ...
- Make-up is a **homogeneous mixture** of several products. Depending on the coloring, different make-up can be prepared with selected colors.
- **Bees wax** (1 grain=1g) and **lanolin** are fatty products that constitute the make-up base.
- **Talc** is used for hiding imperfections during the make-up spreading on the face and gives a mat aspect.
- The **coloring** determines the color and the **preservative** avoids mould development.

Making cosmetics

C2. Lipstick preparation

(duration: about 1 hour - individual)

products

- castor oil
- bees wax (5 grains=5 g)
- isopropyl myristate
- lanolin
- preservative (facultative)
- coloring (facultative)

material

- 1 tank for boiling water
- 1 stove
- 1 measuring cylinder of 25 cm^3
- 2 spatulas
- 1 pot
- 1 measuring cylinder of 10 cm^3
- 1 measure (10 g of lanolin)
- 1 measure (1g of coloring)
- 1 stopped flask
- 1 label sticker

operating procedure

1. **prepare** a boiling water by heating water in a resistant tank placed on a stove
2. **switch** the stove **on**
3. **measure** 11 cm^3 of castor oil with the 25 cm^3 measuring cylinder
4. **pour into** the pot
5. **add** with a spatula 5 grains of bees wax in pot
6. **measure** 2 cm^3 of isopropyl myristate with 10 cm^3 measuring cylinder
7. **pour into** the pot
8. **add** 1 skimmed measure of lanolin with a second spatula
9. **add** 1 hint of spatula of preservative (facultative)
10. **place** the pot in the boiling water
11. **wait** till waxes have completely melt
12. **remove** the pot from boiling water
13. **add** with the clean spatula 1 skimmed measure of coloring (facultative)
14. **carefully mix** with the spatula till a homogeneous mixture is obtained
15. **place** the pot in the boiling water again (about 1 minute)
16. **switch** the stove **off**
17. **remove** the pot from boiling water
18. **carefully mix** the pot content
19. **pour** the pot content **into** the flask
20. **block and label** this flask

remarks

- The prepared lipstick is a **homogeneous mixture** of several products.
- Castor oil, **bees wax** and **lanolin** are fatty products that constitute the lipstick base.
- **Isopropyl myristate** gives the lipstick shiny aspect, the **coloring** determines its color and the **preservative** avoids mould development.

Making cosmetics

C3. Toothpaste preparation

(**duration**: about 1 hour - individual)

products

- glycerin
- cellulose
- demineralized water
- silica gel
- sodium dodecyle sulfate
- sodium fluoride
- preservative (facultative)
- coloring (facultative)
- aroma (facultative)

material

- 1 measuring cylinder of 10 cm^3
- 1 pot
- 1 measure (0,5 g of cellulose, sodium dodecyle sulfate)
- 1 paper hanky
- 2 spatulas
- 1 measuring cylinder of 25 cm^3
- 1 measure(3g of silica gel)
- 1 stopped flask
- 1 label sticker

operating procedure

1. **measure** 10 cm^3 of glycerin with the 10 cm^3 measuring cylinder
2. **pour into** the pot
3. **add** 1 skimmed measure of cellulose with a spatula
4. **wipe** the measure with the hanky
5. **carefully mix** with the same spatula to obtain a translucent liquid
6. **let** this spatula in the pot till the end
7. **measure** 20 cm^3 of demineralized water with the 25 cm^3 measuring cylinder
8. **add** 1 skimmed measure of silica gel with a clean spatula
9. **carefully mix** with the reserved spatula
10. **do** steps 8 and 9 **again** with 1 measure of silica gel
17. **add** 2 skimmed measures of sodium dodecyle sulfate with the clean spatula
18. **add** 5 drops of sodium fluoride
19. **add** 1 hint of spatula of preservative (facultative)
11. **add** 5 drops of coloring (facultative)
12. **add** 5 drops of aroma (facultative)
13. **carefully mix** the pot content
14. **pour** the pot content **into** a flask
15. **block and label** this flask

remarks

- The prepared toothpaste is a **homogeneous mixture** of several products with different properties. Without preservative, it will be advised to store the toothpaste away from light and in a cool area and to throw it as soon as mould will appear.
- **Glycerin** is a wetting agent that is a product which maintains humidity in the mixture by preventing water to evaporate. The toothpaste will not dry so quickly and could be used longer.
- **Cellulose** enables components to link in the mixture.
- **Silica gel** is a lightly **abrasive powder**: it polishes teeth by rubbing them.
  Which abrasive material is used to polish wood for example?.....
- The **detergent** component in this toothpaste is the sodium dodecyle sulfate.
- **Sodium fluoride** brings fluorine that avoids tankteria growth in the mouth and protect teeth from decay.
- **Teeth brushing** with a brush clean by polishing and disperse the dirt with a detergent. **Rinse** with water carry the toothpaste and rubbish. It is reasnded to brush one's teeth after any meal.

Making cosmetics

C4. Soap preparation

(**duration**: about 1 hour - individual)

products

- oil
- ethanol
- sodium hydroxide
- sodium chloride
- perfume (facultative)
- ice

material

- 2 measuring cylinders of 25 cm^3
- 1 pot (heat-resistant)
- 1 labeled flask
- 1 stove
- 1 spatula
- 1 measuring cylinder of 50 cm^3
- 1 funnel
- 1 filter
- 1 pot (adapted to the funnel)
- 1 mould pierced with holes

common material

- 1 ice bath
- 1 tank to heat water
- 1 stove to heat water
- 1 measure of 40cm^3 for boiling water

operating procedure

While the educator **heats** water to boiling:

1. **measure** 20 cm^3 oil with the 25 cm^3 measuring cylinder
2. **pour into** the pot
3. **measure** 20 cm^3 ethanol with the other 25 cm^3 measuring cylinder
4. **pour into** the pot
5. **add** all the packaged solution of sodium hydroxide
6. **switch** the stove **on**
7. **place** the heat-resistant pot on the stove
8. **mix** without stopping with the spatula till obtaining a thick paste
9. **switch** the stove **off**
10. **place** the pot in the ice bath till cooling of the mixture
11. **take the pot out** of the ice bath
12. **let the educator add** 40 cm^3 boiling water in your pot
13. **carefully mix** with the spatula
14. **cool** the mixture in the ice bath
15. **add** 50 cm^3 of sodium chloride solution measured with the 50 cm^3 measuring cylinder
16. **add** 20 drops of perfume (facultative)
17. **carefully mix** the pot content
18. **place** a filter in the funnel
19. **put** the funnel on the flask
20. **slowly pour**, along the spatula, the pot content **into** the filter
21. **wait** till the liquid has run
22. **place** the remaining paste in the mould with the spatula
23. **let dry** this paste in the mould several days
24. **turn out** the soap when it is hard enough

remarks

- The prepared soap is a **detergent**.
- On the contrary to make-up, lipstick and toothpaste, soap is not a mixture of several unchanged products at the end of fabrication. It has been obtained by **chemical reaction**, the starting products being transformed in other products such as soap. This chemical reaction is called **saponification**.
- This transformation requires energy brought by heating: the saponification reaction is **endothermic**.

Learning with a soap film

S1. Soap bubbles liquid preparation (duration: about 30 minutes - individual)

products
- water
- liquid detergent
- glycerin

material
- 1 measuring cylinder of 10 cm^3
- 1 pot
- 1 spatula
- 1 measuring cylinder of 50 cm^3
- 1 stopped flask
- 1 label sticker

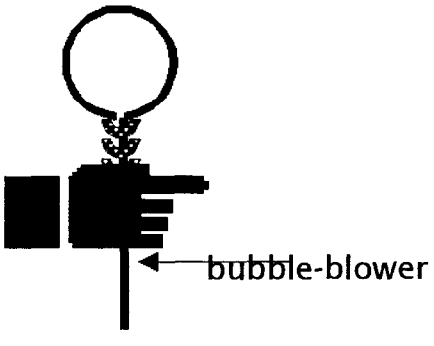
operating procedure
1. **measure** 4 cm^3 of liquid detergent with the 10 cm^3 measuring cylinder
2. **pour into** the pot
3. **add** 45 drops of glycerin
4. **measure** 40 cm^3 water with the 50 cm^3 measuring cylinder
5. **pour into** the pot
6. **mix** with the spatula till obtaining a homogeneous solution
7. **pour** the soap bubbles liquid **into** a flask
8. **block** and **label** this flask
9. **let** the liquid **settle** for several days before using it to make bubbles

all kept proportions

- To realize the following experiment, a lot of soap bubbles liquid is required. Calculate the necessary quantities to prepare 270 cm^3 of this liquid. Fill the following table in:

Product	Volume used in this experiment (cm^3)	Volume used for the following experiment (cm^3)
water	40	
liquid detergent	4	
glycerin	1	
Total: bubbles liquid	45	270

remarks
- **Glycerin** is a wetting agent that is a product which maintains humidity in the mixture by preventing water to evaporate. A soap bubbles liquid that contains glycerin will enable you to realize more resistant, more elastic and bigger bubbles.
- A **soap bubbles liquid** can be prepared with only water and liquid detergent: it is a soap water. However, its resistance would be lower than soap bubbles liquid with glycerin.
- A **bubbles-blower** can be built with a coated wire winded on itself.



Learning with a soap film

S2. A soap film

(duration: about 30 minutes - individual)

products

- water
- soap water

material

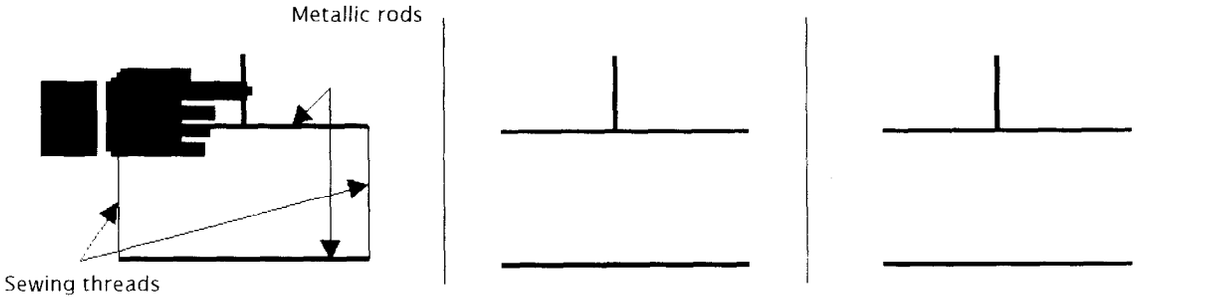
- 2 tanks
- 1 trapeze

operating procedure

1. **completely dip** the trapeze **into** a water tank
2. **slowly take** the trapeze **out** of the water tank
3. **observe and complement** the figure
4. **restart** with the trapeze in a soap water tank
5. **observe and complement** the figure

observations

- Draw the trapeze threads and liquids in the following cases:



Dry trapeze | trapeze out of water | trapeze out of soap water

- Draw the detergent( ) that introduces itself between soap film and surrounding air:

face profile

remarks

- It would be worth doing "water has a "skin"" workshop before this one for the introduction to detergent properties.
- A **soap film** creates itself between the trapeze sides with the soap bubbles liquid. It is made of a thin membrane of water recovered by **detergent** that lies water by its hydrophilic part and the air by its hydrophobic one. Its thickness is higher at the bottom due to **gravity**.
- The soap bubbles liquid contains a liquid detergent that lowers water **surface energy** or **surface tension**. This explains why the soap film surface is smaller than the trapeze one when held in the air.

Learning with a soap film

S3. Soap film elasticity

(duration: about 5 minutes - individual)

products

- soap bubbles liquid

material

- 1 tank
- 1 trapeze
- 1 straw

operating procedure

1. **completely dip** the trapeze into the soap bubbles liquid tank
2. **dip** two fingers into the soap bubbles liquid
3. **pull** the trapeze lower rod with these two fingers to retrieve maximal surface trapeze (as without the soap film)
4. **push** the trapeze lower rod with these two fingers to reduce surface trapeze once again

remarks

- When the trapeze lower rod is pulled to retrieve the initial surface, a "**work**" is undertaken to compensate soap film surface energy: this is a positive work, physically.
- When the trapeze lower rod is pushed to reduce the soap film surface again, a "**work**" is undertaken to emphasize soap film surface energy: this is a negative work, physically.

S4. Minimal surfaces and soap film

(duration: about 5 minutes - individual)

products

- soap bubbles liquid

material

- 1 tank
- 1 trapeze
- 1 straw

operating procedure

1. **completely dip** the trapeze in the soap bubbles liquid tank
2. **dip** a straw end **into** the soap bubbles liquid
3. **carefully blow** in the straw place on the formed soap film
4. **observe** the obtained form

observations

- What is the geometrical form obtained when one blows on the soap film?
  .....
  .....
- How is usually called the obtained form?
  .....
  .....
- Why do you think a trapeze has not been obtained using the trapeze framework?
  .....
  .....
- Justify the obtained form, knowing that the soap film takes the form requiring the minimal surface for a maximal volume of insufflated air.
  .....
  .....

remarks

- The soap film always takes the more stable form with **minimal surface.**
- Engineers and architects use this soap film property to determine which **structure** will be **optimal**, that is with the maximum of stability and using the minimum of material. The soap film gives the answer as well as mathematical models requiring a computer (and even quicker).
- It is possible to make any wire structures to find their minimal surface with soap bubbles liquid, for example a cube, a tetrahedron, a octahedron, a spiral, or any other form.

Learning with a soap film

S5. Soap film auto-cicatrization

(duration: about 30 minutes - individual)

products

- water
- soap bubbles liquid

material

- 1 tank
- 1 trapeze
- 1 straw

operating procedure

1. **dip** the trapeze **into** the soap bubbles liquid
2. **try to pierce** the formed soap film with a dry straw
3. **observe** and **note** your remarks
4. **dip** the trapeze **into** the soap bubbles liquid
5. **dip** a straw end **into** the soap bubbles liquid
6. **try to pierce** the formed soap film with a dry straw end
7. **observe** and **note** your remarks

observations

- Why does the dry straw pierce the soap film?

  .....

- Does a straw recovered with soap bubbles liquid pierce the soap film ?

  .....

remarks

- The **soap film** has been pierced by the dry straw. With the straw wetted by the soap bubbles liquid, the film is pierced but repairs itself with soap bubbles liquid brought by the straw: it is the soap film **auto-cicatrization**.

S6. Soap film and bubbles iridescence

(duration: about 5 minutes - individual)

products

- soap bubbles liquid

material

- 1 tank
- 1 trapeze
- 1 straw
- 1 bubbles-blower

operating procedure

1. **completely dip** the trapeze **into** the soap bubbles liquid
2. **carefully observe** the soap film till it bursts
3. **completely dip** the bubbles-blower **into** the soap bubbles liquid
4. **dip** a straw end **into** the soap bubbles liquid
5. **realize** a big bubble
6. **carefully observe** the bubble till it bursts

observations

- Which colors can you observe on the soap film and bubble?.....

  .....

  .....

- Which is the color you observe on the soap film and bubble just before they burst?

  .....

remarks

- The **soap film** has a thickness in the range of 0,01µm and 1µm (1 micrometer (µm) is equal to 10^{-6} m) what corresponds to a thickness 10 000 and 100 times lower than one of a paper sheet.
- Soap film thickness is more important at the bottom because of **gravity**.
- **Natural light** is made of different colors radiation which form white light when all similarly directed. This one is reflected on thin **soap film** which decomposes it depending on its thickness. Different colors **iridescence** appear as a result of certain **interference** between divers radiation. Irregular thickness soap film leads to color whirls. When the upper part of a film or a bubble becomes very thin, interference causes the subtraction of light, and so the apparition of black zones in the soap film, just before they burst.

Using solar energy

E1. Solar energy

(duration: about 30 minutes - individual pr in group)

products

- water

material

- 2 black stopped pots
- 1 measuring cylinder of 25 cm^3
- 2 alcohol thermometers
- several mirrors (5 or more)

operating procedure

1. **measure** 20 cm^3 water with the 25 cm^3 measuring cylinder
2. **pour** into one of the flasks
3. **add** the same quantity of water in the other flask
4. **pierce** a hole to introduce thermometer in each stopper
5. **block** the two flasks
6. **expose** the two flasks filled with water to the sun
7. **place** a thermometer in each flask
8. **wait** till temperature stabilizes
9. **note** water temperature
10. **place** mirrors en arc around flask n°2
11. **let exposed** to the sun for about 10 minutes
12. **note** water temperature in each flask

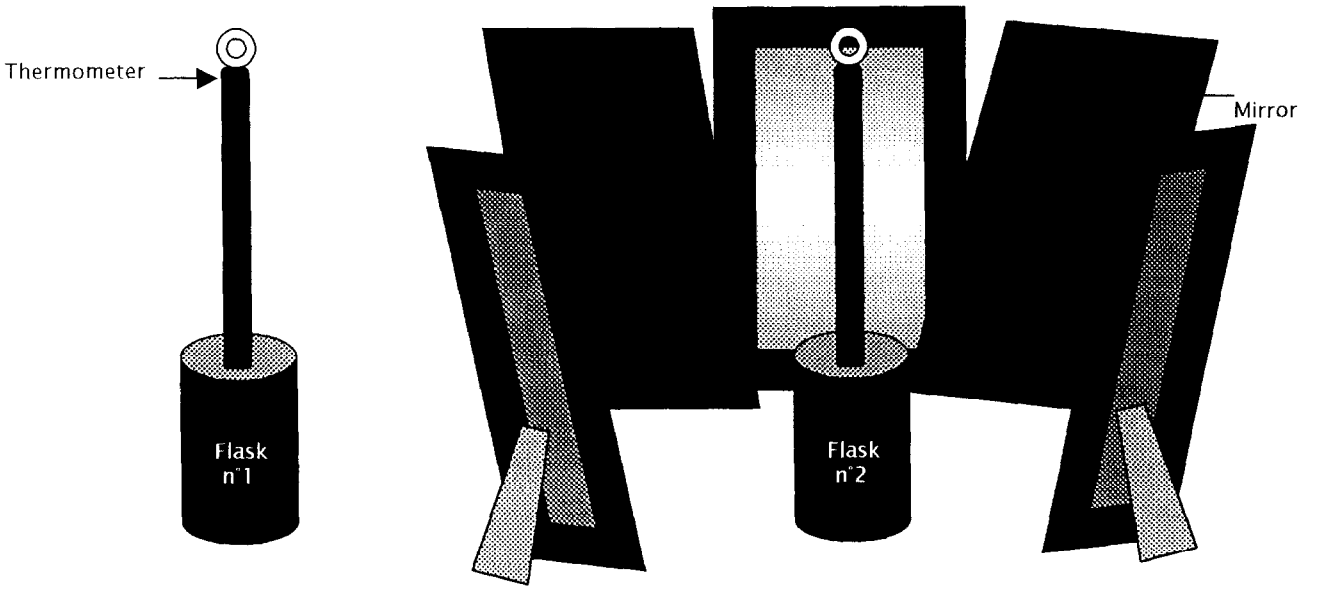
observations

- Fill the following table. What is the role of mirrors?

.....

Flask	n°1	n°2
Initial Temperature (°C)		
Final Temperature (°C)		

- Indicate the liquid level read on thermometers and the temperature at the end of the experiment:



Remarks

- Stars, such as the Sun, produce **energy** that is qualified as "**renewable**" on the opposite to **fossil energies** (coal, petrol, gas) based on limited resources compared to their exploitation rhythm.
- Quote several examples of renewable energy:

.....

- **Solar energy** is transmitted in particular by **light** and can be transformed in **calorific energy** that means in **heat**.

Using solar energy

E2. Building a solar oven

(duration: about 30 minutes - individual or in group)

products

- water

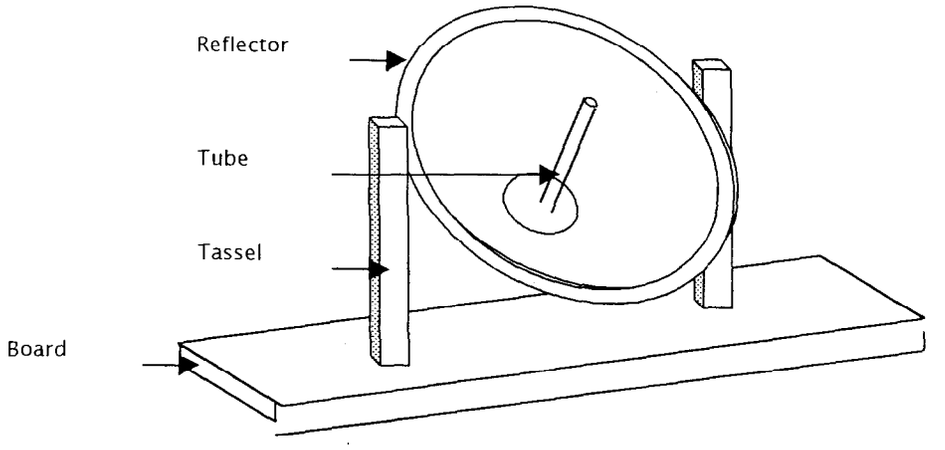
material

- 1 car headlight reflector
- 1 wooden board
- 2 tassels (1cm thick)
- 4 pins
- stopper
- glass tube in Pyrex
- 6 screws
- 2 washers

operating procedure

1. **pierce** two holes diametrically opposed on the headlight reflector edge
2. **introduce** a wood screw in each hole, then a metal washer
3. **fix** screws in tassels
4. **fix** tassels to the wooden board
5. **adapt** a stopper in the heading hole reserved for bulb
6. **place** pins in the stopper to maintain a glass tube
7. **introduce** the other end in one of the holes
8. **direct** the reflector to the Sun
9. **place** the tube base where sun radiation converge

solar oven device



Checking the good functioning of your solar oven

- How could you check the good functioning of your solar oven? Write an operating procedure and realize the experiment without forgetting to compare with a controlled test and fill the following table, for example.

In the tube	beginning	end
Water Volume (cm^3)		
Water Temperature (°C)		
Time (min)		

remark

- **Solar oven** using reflected solar light concentrated by mirrors provide high temperatures required for melting certain materials

Using solar energy

E3. Building of a solar water-heater (duration: about 30 minutes - individual or in group)

products

- water
- black paint
- glue

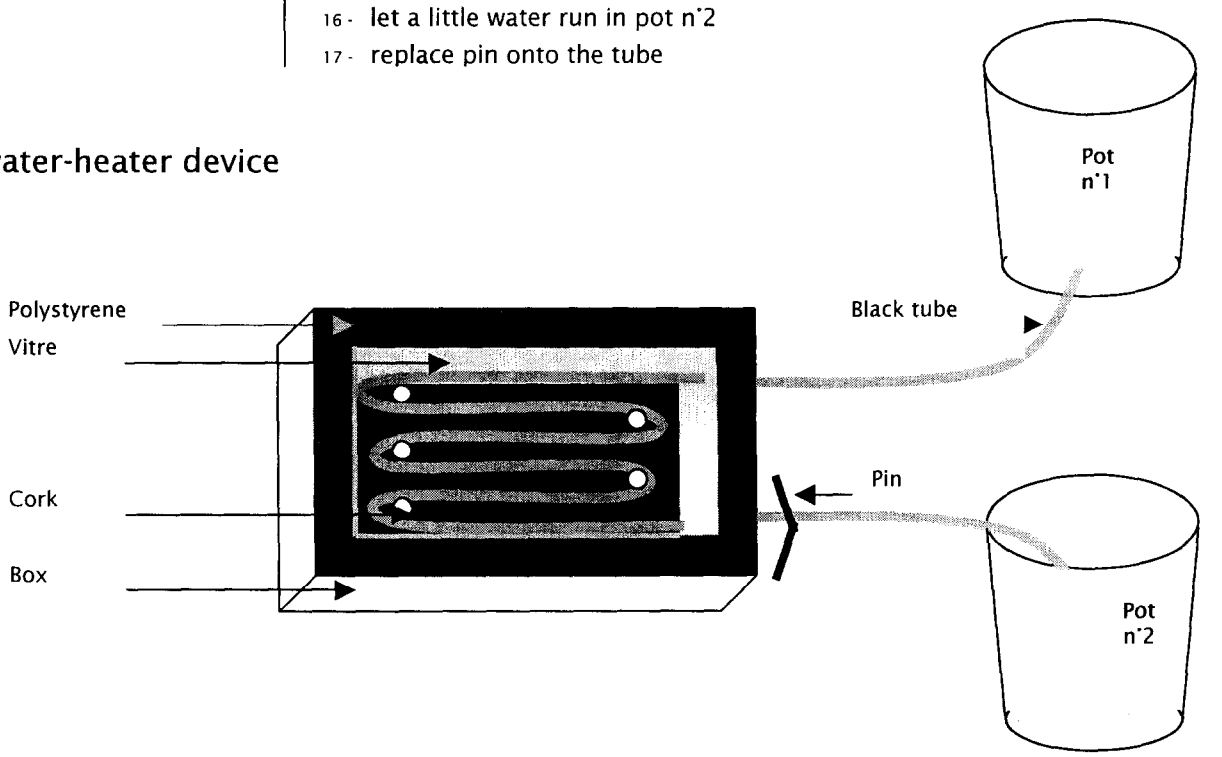
material

- 2 pots
- 1 box
- 1 polystyrene board
- corks
- 1 pane
- 1 black tube
- 1 clothes pin
- (1 alcohol thermometer)

operating procedure

1. paint in black the box bottom
2. pierce two well spaced holes on a box side to introduce the tube
3. glue corks on the box bottom on one side and on the opposite one
4. pierce a hole in a pot to introduce the tube
5. drive a tube end in this hole
6. drive the other tube end in another hole
7. place the tube by winding it up around corks
8. drive a tube end out of the other box hole
9. place a tube end in the other pot
10. place a pin on the tube at the box exit
11. fix the pane in the polystyrene
12. place the polystyrene onto the box
13. fill the pot n°1 with water
14. let exposed to the sun for 1 hour
15. remove pin from the tube
16. let a little water run in pot n°2
17. replace pin onto the tube

solar water-heater device



checking the good functioning of your solar water-heater

- How could you check the good functioning of your solar water-heater? Write an operating procedure and realize the experiment without forgetting to compare with a controlled test.

remark

- Solar energy can be used by solar captors that enable to store heat and to transmit it to water, for example.

Using solar energy

E4. Salt water desalinization (duration: about 30 minutes - individual or in group)

products

- demineralized water
- sodium chloride

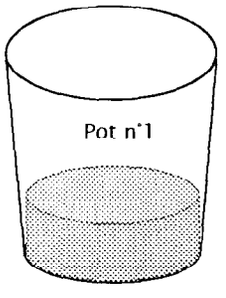
material

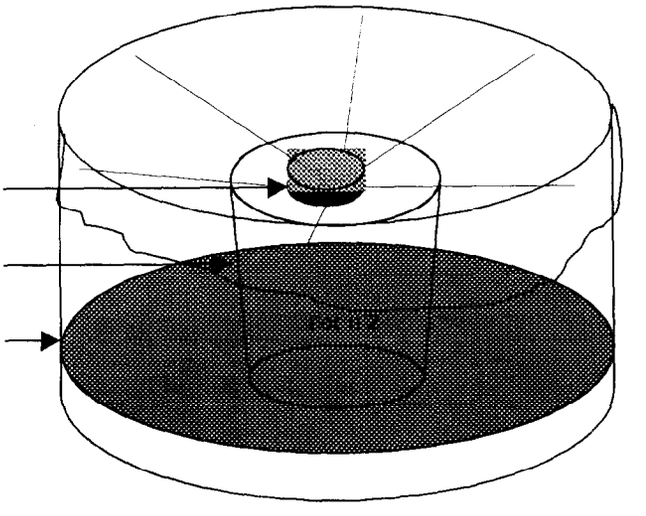
- 1 measuring cylinder of 50 cm^3
- 3 pots
- 1 measure (1.5 g of sodium chloride)
- 1 spatula
- 1 large dish
- 1 plastic foil
- 1 stopper

operating procedure

1. **measure** 50 cm^3 water with a measuring cylinder
2. **pour into** pot n°0
3. **add** a measure of sodium chloride
4. **mix** with the spatula till obtaining a homogeneous solution
5. **pour** salt water **into** the large dish
6. **do** steps 1 to 4 **again** in pot n°1
7. **keep** this mixture as controlled test
8. **put** the pot n°2 at the large dish center
9. **place** a plastic foil on the large dish
10. **place** a stopper above the plastic foil on pot n°2
11. **expose** the large dish to the sun till its content has evaporated
12. **taste** the pot n°2 content
13. **taste** the pot n°1 content

observations





- Fill the following table:

Pot	n°1	n°2
Taste		

- What happened? .....
  .....
- Where is the introduced sodium chloride? .....
  .....

remark

- **Sodium chloride** is the scientific name for **salt**. **Sea water** is salted. It contains between 30 and 35 grams of sodium chloride per liter, being between 1,50 and 1,75 grams for 50 cm^3 sea water.
- Sea water **desalinization** is a useful mean to produce **soft water**. But it requires a lot of energy.

Making or recycling materials

M1. Making buttons from milk

(duration: about 1 hour - individual)

products

- water
- full-cream milk
- lemon juice (or vinegar)
- coloring (facultative)

material

- 1 tank (heat-resistant)
- 1 stove
- 1 measuring cylinder of 25 cm^3
- 2 pots
- 1 spatula
- 1 thin tissue (20cmx20cm)
- 1 stick (for buttons)
- 1 plastic foil

operating procedure

1. **prepare** boiling water by heating water in a resistant tank placed on a stove
2. **switch** the stove **on**
3. **measure** 25 cm^3 of milk with the measuring cylinder
4. **pour** them **into** pot n°1
5. **place** the pot in boiling water
6. **stir** the pot content with the spatula till it has become mild (about 5 minutes)
7. **switch** the stove **off**
8. **remove** pot n°1from boiling water
9. **add** 5 drops of coloring
10. **mix** with the spatula till obtaining a homogeneous solution
11. **continuously stir** with the spatula during the following step
12. **very carefully pour, while stirring,** a few drops of lemon juice in the mild milk till flakes appear, regroup themselves, and the liquid becomes suddenly translucent (between 10 and 20 drops)
13. **place** the thin tissue on a clean pot n°2
14. **pour** all the pot content n°1 **into** pot n°2
15. **remove** the tissue containing a paste comprised of casein
16. **squeeze** the obtained paste by carefully wringing the tissue out
17. **form** a ball with the obtained paste
18. **knead** the obtained paste with hands by forming balls
19. **spread** 1 or 2 balls on the plastic foil
20. **form** buttons by making two holes with the stick (or another form)
21. **let dry** till objects harden (a night)

remarks

- The milk is composed of water (90% in mass), sugars (mostly **lactose**), **proteins** (see "W5. Cloth washing"), fats, minerals (calcium, phosphorus) and vitamins.
- About 85% of milk proteins are of **casein**, a heavy substance or **surface-active** "**macromolecule**" (see "W2. water has a "skin"). What is the role of casein in milk (see "W4. Interest of detergents")?
  .....
- The milk coagulates when salt or acid products are added, such as lemon juice or vinegar: milk then **curdles** when casein separates from milk. Casein proteins have been **denatured** by the addition of lemon juice (citric acid) or vinegar (acetic acid). The acidity of stomach makes proteins coagulate and then slow their digestion because they become less available to **enzymes** (see "W5. Cloth washing").
- **Cow milk** contains more proteins than **human milk**, coagulation being easier with cow milk, but making it also less digest than human milk.
- Milk coagulation is the first step in the preparation of **cheeses**, before their wringing out, salting and refining. By liberating **lactic acid** from the transformation of sugar milk (lactose), lactic bacteria acidify the media and coagulate milk: proteins agglomerate to form a "curdle" that leads to **yoghourts**.
- One of the first **plastics** was made from casein and formaldehyde (to make the material plastic and insoluble): it was called "milkstone" (casein-formol or "Galalith"). **Galalith** is still prepared to make buttons and luxurious pen.

Making or recycling materials

M2. Making a brooch of synthetic resin (duration: about 30 minutes - individual)

products

- Formaldehyde
- Urea
- concentrated chlorhydric acid
- coloring (facultative)

material

- 1 measuring cylinder of 25 cm^3
- 1 pot
- 1 spatula
- 1 safety pin (for a brooch)
- 1 plastic foil

precautions

- wear a lab-cloth, gloves, goggles
- handle in a ventilated area
- use a "pro-pipette" for concentrated acid

operating procedure

1. **measure** 15 cm^3 of formaldehyde with the measuring cylinder
2. **pour** them **into** the pot
3. **add** 5 drops of coloring
4. **dissolve** urea until formaldehyde saturation without heating
5. **stir** the pot content till urea can not dissolve anymore (about 5 minutes)
6. **add** drop to drop, under stirring, few drops of concentrated chlorhydric acid, till the pot content forms a solid (about 5 minutes)
7. **stir** with the spatula until a resin forms and cools
8. **place** this resin, with the spatula, on a plastic foil
9. **form** a brooch by pressing the safety pin on the resin
10. **let dry** until the object hardens (a night)

remarks

- Urea-formol resins preparation by urea condensation with formaldehyde was discovered in 1920.
- Shiny plastics obtained are part of aminoplastic resins, and are used in particular as glues, varnishes, textile finishing.

Making or recycling materials

M3. Making a plastic film (duration: about 30 minutes - individual)

products

- demineralized water
- polyvinyl alcohol (PVA)

material

- 1 measuring cylinder of 25 cm^3
- 1 measure (1,3g of PVA)
- 1 pot (heat-resistant)
- 1 spatula
- 1 stove
- 1 plate (20cm x 20cm)

operating procedure

1. **measure** 25 cm^3 water with the measuring cylinder
2. **pour into** the pot
3. **add** 1 skimmed measure of PVA with a spatula
4. **switch** the stove **on**
5. **place** the heat-resistant pot **on** the stove
6. **carefully mix** until obtaining a translucent solution
7. **remove** the pot **from** the stove
8. **switch** the stove **off**
9. **spread** the pot content in very thin layer on the plate
10. **let dry** this film during one day
    (**or : place** in an oven at 175°C for about 15 minutes **and let dry** until the film hardens)

remarks

- Polyvinyl alcohol (**PVA** or Elvanol) is a **polymer** that was made from a petroleum product, polyvinyl acetate. It is used to make **plastic objects**.
- Plastics can be obtained:
  - from natural substances (Galalith, Celluloïd, Cellophane, etc.)
  - from synthetic substances (condensation resins (Bakelite, Nylon, polyurethane), polymerization resins (Plexiglas, Araldite), silicones, etc.)
- Materials prepared by humans are **synthetic products**, whereas **natural materials** (bones, horns, ivory, tortoiseshell, gelatin, natural resins, etc.). Galalith was prepared to imitate corn and ivory.
- **Synthetic plastics** tend to replace any natural product in daily life and industrial applications, due to their advantageous properties. Their main inconvenient is their **recycling** that is often problematic.
- PVA is soluble in water. It is the reason why a lot of **packaging** dissolve in water. For example, it is used to directly place **dirty clothes** in washing machines because the plastic will dissolve in hot water: thus hospital staff contamination can be prevented.
- In agriculture, in order to prevent contact between skin and toxic pesticides, PVA bags containing pesticides doses are laid down cultures that will liberate the chemical after plastic dissolution into water.
- What will happen if your plastic film is in contact with water ?
  .....
- Write an operating procedure and realize the experiment to check your hypothesis.

Making or recycling materials

M4. Making a polyurethane foam

(duration: about 10 minutes - individual)

products

- di-isocyanate of 4-4'-di-phenylmethane (MDI)
- mixture of polyol and expanding agent

material

- 1 filter paper foil
- 2 pots
- 1 spatula

precautions

- wear a lab-cloth, gloves, goggles
- handle in a ventilated area

operating procedure

1. **place** both pots on the filter paper foil
2. **pour** about 1 cm height of polyisocyanate **into** pot n°1
3. **pour** about 1 cm height of mixture of polyol and expanding agent **into** pot n°2
4. **pour** the pot content n°2 **into** pot n°1
5. **mix** with the spatula until obtaining a homogeneous mixture
6. **wait** a minute and **observe without touching** during 3 minutes
7. you can then **touch** the produced foam

observations

- What happened? .....
  .....
  .....
- How is the foam? .....
- Is pot n°1 content warmer or colder at the end of experiment ? .....

remarks

- **Polyurethane** preparation is obtained by mixing polyisocyanate and polyol, respectively isocyanate and alcohol **polymers**. The expansion as a foam is due to the expanding agent that is vaporized in the atmosphere during the chemical reaction.
- Depending on the **polyol** used, a **smooth foam** or a **rigid foam** can be obtained.
- **Polyurethane** are very spread **polymers**. They are used in particular for isolating houses and seat stuff in automobile industry.
- **WARNING: Polyurethane** foam shall never be burnt as it produces a lethal gas, hydrogen cyanide.

Making or recycling materials

M5. Recycling paper

(**duration**: about 30 minutes - individual)

products

- water
- old newspapers

material

- 1 large plate
- 1 spatula
- 1 measure
- 1 grille
- 1 tank
- 2 absorbent tissues
- 1 roller
- 1 cloth thread
- 2 pins

operating procedure

1. **tear** the newspapers **up** above a large plate
2. **add** water
3. **mix*** the paper paste with the spatula
4. **let** the paper paste **settle** during the night
5. **take** a measure of paper paste
6. **place** the grille on a tank
7. **spread** the paper paste with the spatula in a very thin layer on the grille
8. **place** the grille between two absorbent tissues
9. **squeeze** the grille with the roller
10. **let** paper **dry** by suspending it to a cloth thread with pins

*The paper quality will be better with a food mixer to mix the paper paste.

remarks

- **Paper** is a **material** made of natural vegetal fibers, in particular of wood fibers.
- How many tons of paper does your country produce annually?
  .....
- To produce one ton of paper, about 17 trees are necessary, on the average. How many trees are required for the annual production of paper in your country?
  .....

FURTHER READING

Girls and science and technology education

- Botswana Government (1990) *Women in science and technology.* Science and Technology Roadshow in Botswana, 12-18 August 1990. Ed. Botswana Governement Printer, Gaborone, 36p.
- Erinosho, Stella (1997) *Participation des femmes aux sciences : une analyse des matières au programme des sciences de l'enseignement secondaire.* Ed. Academy Science Publishers, Nairobi, Rapport Abrégé de Recherche, **29**, 23p.
- Rajabu, A. R.M.S. & Chediel, R.W. (1997) *Femmes et filles des communautés locales tanzaniennes : connaissances, attitudes et pratiques sur l'environnement.* Ed. Academy Science Publishers, Nairobi, Rapport Abrégé de Recherche, **35**, 9p.
- Unesco (1997) *Innovations in Science and Technology Education.* (eds:) Jenkins, Edgar W. & Layton, David. Ed.Unesco Publishing, Paris, Vol. VI, 286p.
- Unesco (1992) *Formation scientifique des filles. Un enseignement au-dessus de tout soupçon?* (ed.) Renée Clair. Ed. Unesco Publishing, Paris.
- Zietman, Aletta (1997) *Les cours de mathématiques et de sciences pour les filles : une étude menée au Malawi et en Afrique du Sud.* Ed. Academy Science Publishers, Nairobi, Rapport Abrégé de Recherche, **28**, 19p.

Scientific themes of the document

- Groupe de Recherche en Didactique de la Chimie et quelques enseignants (1990) *Pour une approche méthodologique des sciences expérimentales à l'école primaire : les matières plastiques.* Ed. Centre Régional de Documentation Pédagogique de Poitou-Charentes, 31p.
- Groupe de Recherche en Didactique de la Chimie et quelques enseignants (1989) *Comment fabriquer quelques produits courants ?* Ed.Centre Régional de Documentation Pédagogique de Poitou-Charentes, 84p.
- Groupe de Recherche en Didactique de la Chimie et quelques enseignants (1987) *Manipulations à la portée de tous.* Ed. Centre Régional de Documentation Pédagogique de Poitou-Charentes, 198p.
- Maury, Jean-Pierre (1987) *Les bulles, qu'est-ce que c'est ?* Ed. Ophrys, Collection du Palais de la Découverte, Paris, 93p.
- Katz, David (1991) Soap bubbles 1: solutions and basic tools (March 1991). Soap bubbles 2: why bubbles bounce (May 1991). Soap bubbles 3: the chemistry of a soap bubble (July 1991). Soap bubbles

4: why soap bubbles break and why they are spherical (September 1991). Soap bubbles 5: shapes and colours (November 1991). *Education on chemistry*. 5p.

- Nachtigall, W. (1987) *La nature réinventée*. Ed. Plon.
- This, Hervé (1993) *Les secrets de la casserole*. Ed. Belin. 222p.
- Wick, Walter (1998) *Gouttes d'eau*. Ed. Millepages, 40p.

Other:

- Azar Khalatbari avec Graine de Chimiste (1994) La chimie des farces et attrapes, *Science et Vie Junior*, avril 1994, **58**, pp.18-21.
- De Gennes, Pierre-Gilles & Badoz, Jacques (1994) *Les objets fragiles*. Ed. Librairie Plon. 262p.
- Graine de Chimiste (1995) Dis... pourquoi, *Sciences et Avenir*, avril-mai 1995, hors série, **100**, pp.50-51 (*Les secrets de l'encre invisible*), 64-65 (*La formule du "Slime"*) et 72-75 (*Sous la douche...*).
- Groupe de Recherche en Didactique de la Chimie, Graine de Chimiste et quelques enseignants (1997) *Pour une approche expérimentale de l'eau*. Ed. Centre Régional de Documentation Pédagogique de Poitou-Charentes, 129p.
- Groupe de Recherche en Didactique de la Chimie et quelques enseignants (1990) *Comment faire un spectacle de chimie ?* Ed.Centre Régional de Documentation Pédagogique de Poitou-Charentes, 65p.
- Groupe de Recherche en Didactique de la Chimie et quelques enseignants (1985) *Introduction des sciences expérimentales à travers la chimie dans l'enseignement primaire : étude de la notion d'acidité*. Ed. Centre Régional de Documentation Pédagogique de Poitou-Charentes, 67p.
- Lutfi, Mansur (1988) *Cotidiano e educação em química*. Ed. Livraria Unijuí Editora, Ijuí, Brésil, 224p.
- Matricon, Jean & Palais de la Découverte (1990) *Cuisine et molécules*. Ed. Hachette Jeunesse, **78**, 77p.
- Les petits débrouillards (1989) *40 expériences faciles à réaliser*. Ed. Belin, **3**, 77p.
- Thibault, Janine, Davous, Dominique & Masson, Arlette (1993) Une approche interactive de la chimie. *Didaskalia*. **2**, pp.121-130.
- Unesco (1974) *Nouveau manuel de l'Unesco pour l'enseignement des sciences*. Ed.Unesco Publishing, Paris, 281p.