WP3
Chemical Care

European Science and Technology in Action:
Building Links with Industry, Schools and Home

Work Package 3
UNIT CHEMICAL CARE
Classroom Materials

European Science and Technology in Action:
Building Links with Industry, Schools and Home

Lead partner for unit Leibniz- Institute for Science and Mathematics Education (IPN)

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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B. Classroom Materials

SUB UNIT 1:

Become a household detective – use and explore your scientific expertise!
Scientists analyse phenomena in nature and in man-made environments. They carry out experiments to test if their expectations – they call them hypotheses – were correct or false. They can then use their knowledge to optimize processes, for example, or they offer their knowledge to engineers and other experts who can use it to design new techniques and devices.
Of course, scientists have modern equipment in their laboratories to get very good and trustful results, but you can also carry out a lot of such investigations in your own house. Become a scientific household detective!

Activity 1.1

Before you start, you should think about the questions you want to answer, the things you want to find out. Let´s take the example of chemistry, maybe you think about something like…

- Where do we have chemical substances in the house, what do we use them for?
- Which of these substances may be dangerous, how do we have to treat them correctly?
- Where can chemical substances help to avoid natural risks?
- Where do we find and use chemical reactions in the household? Why do we use them?
- ...

See if you can find more questions and discuss them with your detective team!

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Activity 1.2

Let's see how you could proceed to investigate some of your "research questions". Scientists write down what they expect before they start, they call these assumptions "hypotheses". Develop some hypotheses for your questions in your detective team! Use the knowledge you have about products and processes in the house or think about what you have heard on TV or found in the internet.

Our hypotheses for our research questions are:

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Activity 1.3

Now you need a good working plan, how do you wish to proceed and what kind of equipment do you need? Who in your group is going to do what?

To investigate where you might find chemical substances or chemical reactions in your household, you first have to define what chemical substances (often just called chemicals) and chemical reactions are. Where can you look for explanations? Of course in the internet, but those explanations might be too advanced as they might have been written for experts. Try your chemistry book as an alternative as well ☺.

Definitions of chemical substances:

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Definitions of chemical reactions:

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You will have found out that all substances can be called chemicals, did you expect that? Outside the world of chemists, many people think that chemicals are always dangerous and that we better avoid getting in contact with them. You can interview your friends and parents to see what they think about chemicals…

For a chemist, every substance is a chemical with properties he / she can describe and investigate and with a certain structure he can show with the help of models. Why do chemists have to use models to do so? Well, because chemists cannot see the structure of substances, build up by atoms, with their eyes! But this is something you will explore later…
Let´s come back to your search for chemicals in the household. What can you do to find them? You can

- read descriptions of products such as detergents, food, batteries…;
- look for substances in containers like your salt container, a soap container, …

Now you can go look for some chemicals in your household. Write down which chemicals you have found:

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Which way might be better for your safety?

To deal with chemicals you have to learn some safety measures before. You will find the necessary symbols and information in your textbook, so develop a poster in your detective team that you can always take out and check before you get in touch with chemicals!

Template for your poster:

Now, when you have found some chemicals in your household, what could you do to find out more about such chemicals? Again, you can

- describe them according to how they look like and develop systems to categorize them;
- read descriptions of products such as detergents, food, batteries… or
- you can carry out experiments, that´s what chemists do!

Start with some simple substances and a simple system of categorization: Look for all white substances in your household and describe them according to what they look like. You can also make pictures. Think about what you could use to see more? Black paper, a microscope, …?

Present your categorization scheme and pictures to your detective team.

Activity 1.4

To carry out an experiment, you need laboratory equipment, of course. Have a look in your book again and copy some of the equipment you find there in your detective investigation book. Think about the different functions of the tools you have found and write them down next to each tool.

Piece of equipment:	functions of piece of equipment:
	___________________________
	___________________________
	___________________________

Every experiment is related to a question again, such as:

- Can I burn the substance?
- Is the substance soluble in water?
- …

Think about more questions in your detective team and write them down in your book.

Chemists often also use other substances to test what they have found; they call some of them indicators. Maybe you can use them as well in your school?
Show your ideas to your teacher to see which experiments you can actually carry out without any danger for yourself and others, because this is always rule N°1 for every chemist!

Now take your white substances which you have found in your household and carry out the experiments you have decided on with your teacher.

As a good scientific detective, you have to document what you have done in a good way, of course, to make sure that you can tell your results in a convincing way to others later on. How would you design such a good documentation? Make a suggestion in your detective team and discuss it with other detective teams on a detective conference!

Are you now ready to carry out your experiments? Check all the safety measures again, collect the material you need, talk to the teacher once more and then start! No, stop, think about what you have to consider for being able to compare the different white substances before you start! The following questions might help you to do so:

- Can you just take any amount of a substance to test the burning or to test the solubility, for example?
- Can you just take water from the tab without controlling anything to test solubility?
- …

Okay, now you can start! And don't forget to observe carefully and to document everything as a real scientist detective!

Activity 1.5

After having characterized your substances, think about the use of the different chemicals. Can you explain what you use them for with the knowledge you have now gained from your chemical analyses and observations? Develop a short advertising statement for one of your substances saying why something is good to be used for like
“You can solve XXg of salt in water so every soup will be as salty as you would like to have it!”
“My washing powder is basic with a pH of XX so it will clean your dirty washing well!”

My advertising statement:

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Activity 1.6

In the beginning, we also said that some chemicals are used to avoid risks in the household, what could those risks be?

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Think about detergents and cleaning agents, why is it necessary to use them in your household? Find some reasons in your team:

Activity 1.7

To get rid of dirt or microorganisms such as bacteria and mold, you can use chemicals. But how can you choose the right chemical substance for the different types of dirt and bacteria? Do you have an idea how to check whether bacteria have been removed?
Again, you have to know more about the chemicals, but also about the processes that start when you give a chemical to a piece of dirt or to bacteria, for example.
Let´s start with dirt… Which properties and characteristics do you know about dirt? Start to write them in the first column of a table!

Properties of dirt			
Colour			
Left overs of salt, sugar, …			
Oil			
…			

Now add some cleaners you know in the first row of the table. Your table might look like this:

Properties of dirt	Water	Citric Acid cleaner	Washing powder
Colour			
Left overs of salt, sugar, …			
Oil			
…			

Now think about properties you have found out about some chemicals, how might they help to decide on the best cleaner? Here comes one example: You learned that some chemicals are soluble in water, which kind of dirt could you delete just with water?
Insert your conclusions in the table as well. Your table might look like this:

Properties of dirt	Water	Citric Acid cleaner	Washing powder
Colour			
Left overs of salt, sugar, …	Salt and sugar are soluble in water, so water can be used to get rid of them.		
Oil	Oil is not soluble in water so we can´t use water for oil stains.		
…			

Activity 1.8

Again, you can also use information you can get on chemicals you cannot easily analyse at school. Washing powders are such an example. While salt is just one chemical substance (the chemist calls it a *pure substance*), washing powder is a mixture of several substances. Why is that the case? Because you need many different chemicals to get rid of different types of dirt! You need the main component which is “basic” to destroy fatty dirt pieces, for example. You need another substance to get rid of unwanted colours, e.g. from juices, this is reached by a chemical reaction taking place in your washing machine which destroys the colour substance. You will probably find some information on washing powder in the internet, add that to your table as well!

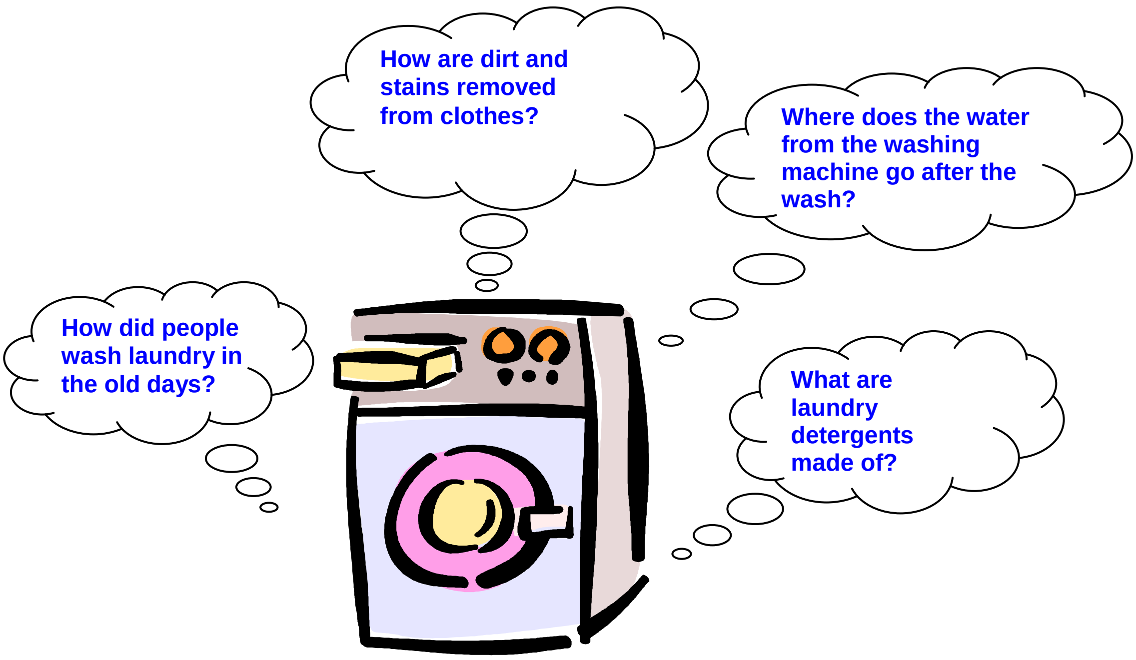
Properties of dirt	Water	Citric Acid cleaner	Washing powder
Colour			Contains a chemical that destroys colors.
Left overs of salt, sugar, …	Salt and sugar are soluble in water, so water can be used to get rid of them.		
Oil	Oil is not soluble in water so we can´t use water for oil spots.		
…			

At this point, you can perform several experiments. Some suggestions of experiments are given on the following pages:

Additional worksheets (Source: Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Worksheet 1: Introduction and safety information[1]

Laundry washing is an everyday activity in modern homes. You might have helped with the washing now and then, or even done it yourself. Perhaps you have even asked yourself one of the following questions:

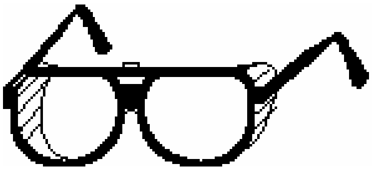


You can answer these questions with the help of the following worksheets and experiments. However, you should pay careful attention to the following:

- **Before you start, read the worksheet or instructions so that you know what you are going to do.**
- **Then, before you do anything else, check that all the materials and/or chemicals you need are at hand. If anything is missing, inform your teacher.**
- **Communicate quietly with the other members of your work group, so that you don't disturb the other groups.**
- **After an experiment, clear up the tables or benches. Dispose of the used chemicals, clean the apparatus, etc.**

Safety instructions

At the learning stations you will work with substances you are familiar with from everyday life: soap and laundry detergents. Nevertheless, safety instructions have to be complied with during experiments. Naturally this includes wearing protective goggles.



Task

1) Why do people not wear protective goggles at home when working with laundry detergents?
2) Which other basic rules for carrying out experiments can you remember?

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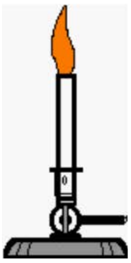
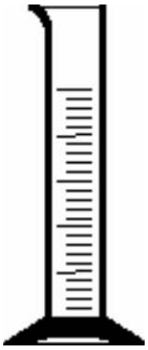
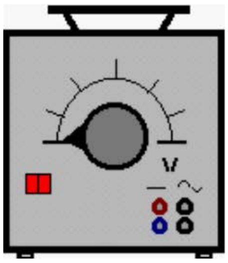


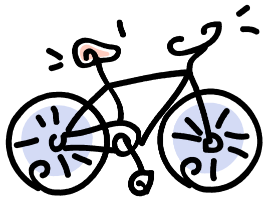




[1] Worksheet taken from:
Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Worksheet 2: How are stains and dirt removed from clothes?[2]

Imagine the following situation: You are cleaning your bicycle before you go for a ride. When everything is nice and clean, you want to oil the bicycle chain quickly. You hurriedly open the bottle containing the bicycle oil – and some of the oil splashes out onto your new white T-shirt. You want to wash the oil out again immediately, so you go into the kitchen where there is a hot water and a cold water tap. Will you succeed in removing the oil with water?



Tasks

1) Plan an experiment with which you can find out whether the oil stain can be removed with water. Make a sketch of the experiment first, and then briefly write down what you are going to do. Can you vary any of the conditions?
2) Carry out your experiment and write down what you observed. Were you able to remove the stain with water?
3) As a group, discuss what else you could use to remove the oil stain. When you have decided what to do, write it down and then carry out a new experiment to remove the stain. Write down what you observed and the result.

[2] Worksheet taken from:
Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Worksheet 3: The influence of temperature on wash performance[3]

In this experiment you have to find out whether the wash performance remains the same at different temperatures or whether it changes. To do this, you will be given cocoa-stained cotton cloths, which you will wash at different temperatures.

Tasks

1) Plan an experiment, with which you can test wash performance at different temperatures. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record the wash result.
3) At which temperatures did you obtain the best wash result?
4) Give reasons why laundry should or should not always be washed at a low temperature (30°C).

[3] Worksheet taken from:
Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Worksheet 4: Laundry detergents *then* and now[4]

Anna browses through her grandmother's photo album. On one of the photos she sees a group of women standing behind big wooden tubs. Steam is rising from the tubs. "What are they doing?", asks Anna. "That was the big washday", says Grandmother. "It was hard work then …"

A washday used to take hours, and sometimes even days. The heavy work could scarcely be carried out by one person alone. There were professional washerwomen, who would carry out the family's big wash, as long ago as the 16th century.

Laundry can now be washed easily and quickly, thanks to advanced detergents and washing machines. The following text tells you about the development of laundry washing and laundry detergents, using the laundry detergent Persil® as an example.

Tasks

1) Read the information on the development of the laundry detergent and the technology of laundry washing in **Material 1**. Each member of your group should read one text. Under the text are several illustrations, which you have to arrange in the right sequence. Draw up a timeline, in which you can glue the illustrations and write or glue information about the development of laundry washing and laundry detergents.
2) Some of the text fields in **Material 1** are empty. Ask your parents and/or grandparents what changes they have seen in laundry washing. Compare their answers in your group and write short texts about them in the empty fields. Add these texts to your timeline.
3) **Material 2** shows an advertising poster for Persil®, the **self-acting detergent**. What do you think "self-acting" means? Write your answer in the field under the advertising poster.

[4] Worksheet and Materials 1-2 taken from:
Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Material 1

The development of the laundry detergent

In **1907**, the Henkel company launched a totally new laundry detergent: Persil. It was the first German washing powder with simultaneous bleaching action, which meant that laundry no longer had to spread out on the grass to be bleached by sunlight.

From the **2nd century AD,** soap was used to wash laundry.

The first “washing powder” then became available around **1880**. Initially, however, it consisted of powdered soap. Ever new formulations were subsequently developed.

By **about 60 AD** the Romans and Egyptians were using first cold and then hot water for washing their laundry. Aids such as sand, urine or soapwort were often added to the water to enhance the wash performance.

The development of laundry technology

In the late 19th and early 20th century, laundry was spread out on the grass after washing, so that it would bleach in the sun. This made clothes appear clean and fresh.

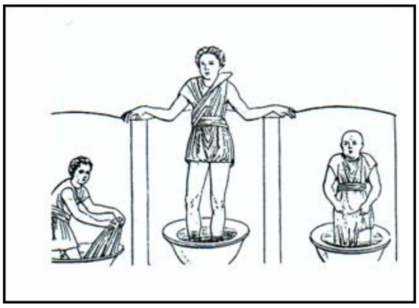
10th century: The first washing device appeared – a bat or paddle, consisting of a wooden board with a handle, with which the laundry was beaten. Laundry was also often beaten on flat stones.

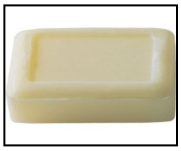
In the **18th century**, a machine was developed for wringing out the wet laundry.

Around 60 AD, laundry was carried out in ancient Egypt and Rome by men, who trampled it in large tubs until it was clean.


SOAP
POWDER


Persil
das selbsttätige Waschmittel.
Alleinige Fabrikanten Henkel & Co. Düsseldorf.





Material 2

The term “self-active” means …

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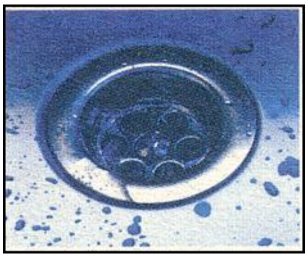
Worksheet 5: Laundry detergents and the environment[5]

After the laundry has been washed, it is clean again – but what about the water that leaves the washing machine? Just as when you shower, take a bath, clean your teeth, wash the dishes, etc., laundry washing generates wastewater. What happens to this wastewater?



You probably know that household wastewater passes through the drains and sewers into a sewage treatment plant. It passes through a number of treatment stages in the sewage plant before it is clean enough to be discharged into surface water.

Tasks

1) Try to treat the wastewater you have been given, using the substance separation methods with which you are already familiar. In **Material 3** you will find the apparatus and materials you are to use. Which substances can and cannot be removed? Write your result in the table.
2) Read **Material 4** to find out about wastewater treatment in sewage treatment plants. Each member of your group should read one information text. Which of the substance separation methods that you used can you find in the text?

[5] Worksheet and Materials 3-4 taken from:
Henkel (2008): Sustainable washing for a clean environment – Chemistry for beginners (11 – 13 year old).

Material 3

You can use the following apparatus and materials

- Beakers
- Glass funnels
- Filter paper
- Coarse sieve
- Fine sieve
- Tweezers

Your wastewater contains:

water, bits of paper handkerchiefs, vegetable scraps, sand, washing powder

Substance	Removed with …
Bits of paper handkerchiefs	
Washing powder	
Sand	
Vegetable scraps	

Disposal

- Put the bits of paper handkerchiefs and the vegetable scraps in the waste bin
- Put the sand in the sand bucket
- Pour the residual wastewater down the sink

Material 4

How does a sewage treatment plant work?

1) First of all the wastewater passes through the mechanical treatment stage. A raked bar screen holds back any relatively large objects in the wastewater, such as pieces of wood, plastic bags or cloths.

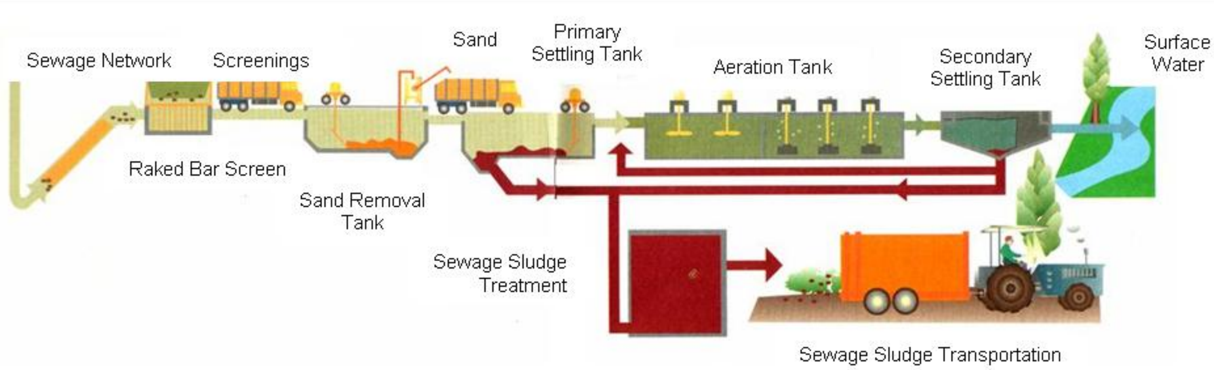
2) The remaining dirty water is then passed through a sand removal tank. Most of the sand settles out there. The water then runs into a primary settling tank, where substances such as food residues can settle on the floor of the tank.

3) The partially cleaned water then flows into an aeration tank, into which air is blown. The bacteria in this tank digest and break down the residual substances in the wastewater. This is referred to as biological treatment.

4) The secondary settling tank is part of the biological treatment stage. Bacteria and residual contaminating substances settle on the bottom of the tank as sludge. After passing through all these stages, the treated water can be discharged into a nearby river.

5) Besides mechanical and biological treatment, there is also chemical treatment. This is the use of chemicals to remove contaminating substances that are still present in the wastewater. This treatment stage is often not present in older sewage treatment plants.

Sketch of a sewage treatment plant



Where are the methods of substance preparation that you already know about?

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Activity 1.9

So far, you needed some chemical knowledge to be a successful household detective. Now we will demand some biology as well! Why? Because you shall be looking for bacteria and other microorganisms or the risk of microbial growth which you do not want in your household!
Of course, not all bacteria are unwanted. You have plenty of them on your skin, in your mouth or in your digestion system. They actually help you, but there are also bacteria that might cause illnesses; and those have to be avoided, of course!
Think again in your detective team: Where would you expect risks for the growth of unwanted bacteria or mold in your household?

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As you cannot see bacteria, you need to set up an experiment again. You can catch bacteria and let them grow in a safe environment when you use agar plates. Talk to your biology teacher about how to prepare them, how to use them in a safe way for yourself and others and plan your experiment – become a bacteria detective this time!

You could perform the following experiment:

Experiment 1: Finding bacteria[6]

Apparatus and chemicals

- 6 petri dishes (with lids) with nutrient agar for usage as contact plates or special contact plates
- overhead marker
- tape (eg. Tesa® film)
- cotton swabs (sterile, new box), sterile moistening liquid (e.g. water)
- hand disinfectant

Safety

Observe all safety measures regarding the handling of bacteria! Wear your safety goggles! After sealing the petri dishes, do not open them again!

Procedure

- Touch the surfaces where you expect bacteria with the nutrient agar in a petri dish or wipe the surface with a moistened cotton swab taken from a newly opened box. Then wipe the cotton swab in zig-zag lines across the agar. Seal the contact plates/ petri dishes immediately with tape. Note on each plate where the sample is from and incubate them for 48 hours at 37°C or 5-7 days at room temperature.
- After incubation, compare the different plates.
- Describe grown colonies with magnifying lens, if available.
- You may examine the bacteria under a microscope.

Note here which surface you tested along with your observation after incubation:

Disposal

- Contact plates should be sterilized / autoclaved.
- All material that has had contact with bacteria should be disinfected.

[6] Source (adapted from):

Wagner, Günter und Blank-Rothenburg, Helga (2001). Bei welcher Temperatur wird Wäsche hygienisch sauber - Wirksamkeit verschiedener Haushaltsreiniger auf ihre antibakterielle Wirkung. *Naturwissenschaften im Unterricht - Chemie,* 12(63), 51-52.

SUB UNIT 2:

Substances in different cleaning agents

The students set up a table of cleaning agents and the substances named as ingredients in those products.
Exemplarily, the content and the effects of acids as ingredients or cleaning agents can be investigated by the following experiments (see material), taken from the German project "Chemie fuers Leben" (also adapted in "Chemie im Kontext").

Activity 2.1 Which household products contain acids?[7]

Apparatus and materials

- filters, round (Ø minimum of 10 cm)
- large Petri dish
- disposable pipettes
- spatula
- markers for writing on filter
- indicator made from red cabbage
- lemon cleaner
- substance for decalcifying
- lemon juice concentrate
- essence of vinegar
- other cleaners…

Safety

Observe all safety measures regarding the handling of acids as printed on the labels! Wear your safety goggles!

Procedure:

- Soak the round filter in red cabbage indicator and dry (air dry, use hair dryer or put on radiator) in a Petri dish. Based on the indicator's intensity, the process may have to be repeated several times.
- Use pipette or spatula to apply small sample of the substances to be analysed to filter and mark the spots accordingly.

Disposal:

- After diluting, pour the solutions down the sink. Put the filter in the waste bin.

[7] Source (adapted from):
http://sinus-transfer.uni-bayreuth.de/fileadmin/MaterialienBT/Skript_Flint.pdf

Activity 2.2 Compare the amount of acid in different household products[8]

Apparatus and materials

- beaker (150 ml)
- measuring cylinder (50 ml)
- magnetic stirrer and stir bar
- buret (25 ml)
- funnel
- destilled water
- rinse aid
- sodium hydroxide solution (c = 0.5 mol/l)
- universal indicator

Safety

Observe all safety measures regarding the handling of acids! Wear your safety goggles!

Procedure

- Pour 10 ml of rinse aid into the measuring cylinder and add distilled water to yield 50 ml of solution.
- Pour the solution into a beaker and add a few drops of universal indicator.
- Fill the sodium hydroxide solution into the burette.
- While stirring, titrate in 0.5 ml-steps until the solution reaches its point of change.

Disposal:

- After diluting, pour the solutions down the sink

[8] Source (adapted from):
Freienberg, Julia (2002). „Chemie fürs Leben – ein neuer Ansatz für den Chemieunterricht am Beispiel der Behandlung von Säuren, Laugen und Salzen in der Sekundarstufe I sowie Anknüpfungsmöglichkeiten für die Sekundarstufe II“, Dissertation, University of Rostock 18.12.2002.

Activity 2.3 Why do companies include acids into cleaning products? – Intended effects[9]

Apparatus and materials

- Water heater with lime scale build-up
- Essence of vinegar or decalcifying substance as bought in the store

Safety

Observe all safety measures regarding the handling of acids! Wear your safety goggles!

Procedure

- Dilute some essence of vinegar with water in a ration of 1:5.
- Pour the solution into the water heater and boil it. Rinse afterwards and compare the look of the interior of the water heater.
- For using the decalcifying substance as bought in the store, follow its instructions.
- According to the degree of lime scale build-up, you may have to repeat the process a few times.

Disposal

- After diluting, pour the solutions down the sink.

[9] Source (adapted from):
Freienberg, Julia (2002). „Chemie fürs Leben – ein neuer Ansatz für den Chemieunterricht am Beispiel der Behandlung von Säuren, Laugen und Salzen in der Sekundarstufe I sowie Anknüpfungsmöglichkeiten für die Sekundarstufe II“, Dissertation, University of Rostock 18.12.2002.

Activity 2.4 Which effects can acids have on different materials and on our health? – Not intended effects[10]

2.4.1 Effect of acid on bones

Apparatus and materials

- 1 large test tube (Ø 3 cm)
- decalcifying agent, e.g. citric acid solution or decalcifying substance as bought in the store
- long and thin bone from chicken, duck or goose; cleaned

Safety

Observe all safety measures regarding the handling of acids! Wear your safety goggles!

Procedure

- Put the bone in a test tube and add enough decalcifying solution to completely cover the bone.
- In case the bone does not stay submerged, you can hold it in place by covering the test tube with a (pierced!) stopper.
- Leave the test tube sit for several days according to the bone's thickness, renewing the solution every day.

Disposal

- After diluting, pour the solutions down the sink. Put the solids in the waste bin.

[10] Source (adapted from): http://sinus-transfer.uni-bayreuth.de/fileadmin/MaterialienBT/Skript_Flint.pdf

2.4.2 Closer investigation of the products of the reaction between marble (chalk) and acids[11]

Apparatus and materials

- 1 test tube for each acidic solution to be analysed
- matching pierced stoppers
- fermentation locks, one for each test tube
- spoon
- glas stirring rod
- crucible tongs
- gas burner
- various acidic solutions to be analysed
- very small pieces of marble (or limestone pieces)
- calcium hydroxide solution
- indicator made from red cabbage

Safety

Observe all safety measures regarding the handling of acids as printed on the labels! Wear your safety goggles!

Procedure

- Fill each test tube up to about a third of its volume with the solutions to be analysed and add several drops of indicator.
- Fill the fermentation locks with the calcium hydroxide solution.
- Add several pieces of marble (or limestone) to each solution (to a heigth of about 1 cm) and close the test tubes quickly with the prepared fermentation locks.
- After a few minutes, remove several drops of each test tube using the glas stirring rod and collect them on the spoon. With the spoon, slowly let the liquid evaporate over the gas burner.

Disposal

- After diluting, pour the solutions down the sink.

[11] Source (adapted from):
http://sinus-transfer.uni-bayreuth.de/fileadmin/MaterialienBT/Skript_Flint.pdf

2.4.3 Reaction between acids and metals[12]

Apparatus and materials

- 4 large and 1 small test tubes for each acidic solution to be analysed
- matching pierced stoppers with a short tube inserted
- stand for test tubes
- watchglas
- crucible tongs
- glass stirring rod
- spoon
- gas burner
- various acidic solutions to be analysed
- magnesium (e.g.pencil sharpener)
- zink (e.g. zinc-plated roofing nails, zinc granules or pieces of a zinc roof gutter)
- iron (e.g. iron nails, iron wool)
- copper (e.g. copper wire)
- indicator

Safety

Observe all safety measures regarding the handling of acids as printed on the labels! Wear your safety goggles!

Procedure

- Fill each of the 4 large test tubes up to about two thirds of its volume with the solutions to be analysed and add several drops of indicator.
- Add one piece of metal to the first test tube and close the test tube with the pierced stopper with a short tube inserted.
- Collect the gas that is generated with a small test tube and perform the test for hydrogen/oxygen gas.
- Proceed accordingly with the other pieces of metal.
- After the reaction subsides, remove several drops of each test tube using the glas stirring rod and collect them on the spoon. With the spoon, slowly let the liquid evaporate over the gas burner.

Diposal

- After diluting, pour the solutions down the sink. Put the solids in the waste bin.

[12] Source (adapted from):
http://sinus-transfer.uni-bayreuth.de/fileadmin/MaterialienBT/Skript_Flint.pdf

2.4.4 Reaction between acid and organic substances[13]

Apparatus and materials

- 1 test tube for each acidic solution to be analyzed
- stand for test tubes
- spatula
- tweezers
- paper towels
- various acidic solutions to be analysed (about 10 ml each)
- several small pieces of raw meat or egg white

Safety

Observe all safety measures regarding the handling of acids as printed on the labels! Wear your safety goggles!

Procedure

- Fill each test tube up to about a third of its volume with the solutions to be analysed and add a piece of raw meat to each.
- Leave the test tube sit for several days, renewing the solution every day.
- Remove the solutions after several days and put the solid remains on a paper towel. Analyse the consistency of the remains by pushing down on them with a spatula.

Disposal

- After diluting, pour the solutions down the sink. Put the solids in the waste bin.

[13] Source (adapted from):
http://sinus-transfer.uni-bayreuth.de/fileadmin/MaterialienBT/Skript_Flint.pdf

2.4.5. “Getting rid” of acids

1. Knowing how much acid is in a particular household product, is it ok for the environment to simply have this acidic solution go down the drain? Search for information on what industry does before disposing of acidic solutions, if any.

2. Research also, which options you have in the chemistry lab to make solutions less acidic. Discuss your findings and come up with an experiment to decrease the acidity of a vinegar solution.

Acitivity 2.5: Comparison of the effectiveness of different household detergents[14]

Apparatus and materials

- 5 petri dishes (with lids) with nutrient agar for usage as contact plates
- different household detergents (such as Bref Power®, DER GENERAL®, Sargrotan®; all of these detergents have antimicrobial claim, for reference purposes, other detergents might be investigated also)
- overhead marker
- tape (e.g. Tesa® film)
- cotton swabs (sterile, new box), sterile moistening liquid (e.g. water)
- paper towel
- hand disinfectant

Safety

Observe all safety measures regarding the handling of bacteria and acids/bases as printed on the cleaners' labels! Wear your safety goggles! After sealing the petri dishes, do not open them again!

Procedure

- Divide surface to be tested into five parts.
- Clean the first part with a disinfectant according to its instructions. Clean the second part with an all-purpose cleaner according to its instructions. Clean the third part with an antibacterial all-purpose cleaner according to its instructions and the fourth with warm water. Use part number 5 as a reference, that is leave the surface without any cleaner applied.
- Touch the cleaned surface with a petri dish or wipe the table with a moistened cotton swab taken from a newly opened box. Then wipe the cotton swab in zig-zag lines across the agar.Seal the contact plates immediately with tape. Note on each plate which cleaner has been used on the surface before. Incubate plates for 48 hours at 37°C or 5-7 days at room temperature.
- After incubation, compare the different plates.

Disposal

- Contact plates should be sterilized / autoclaved.
- All material that has had contact with bacteria should be disinfected.

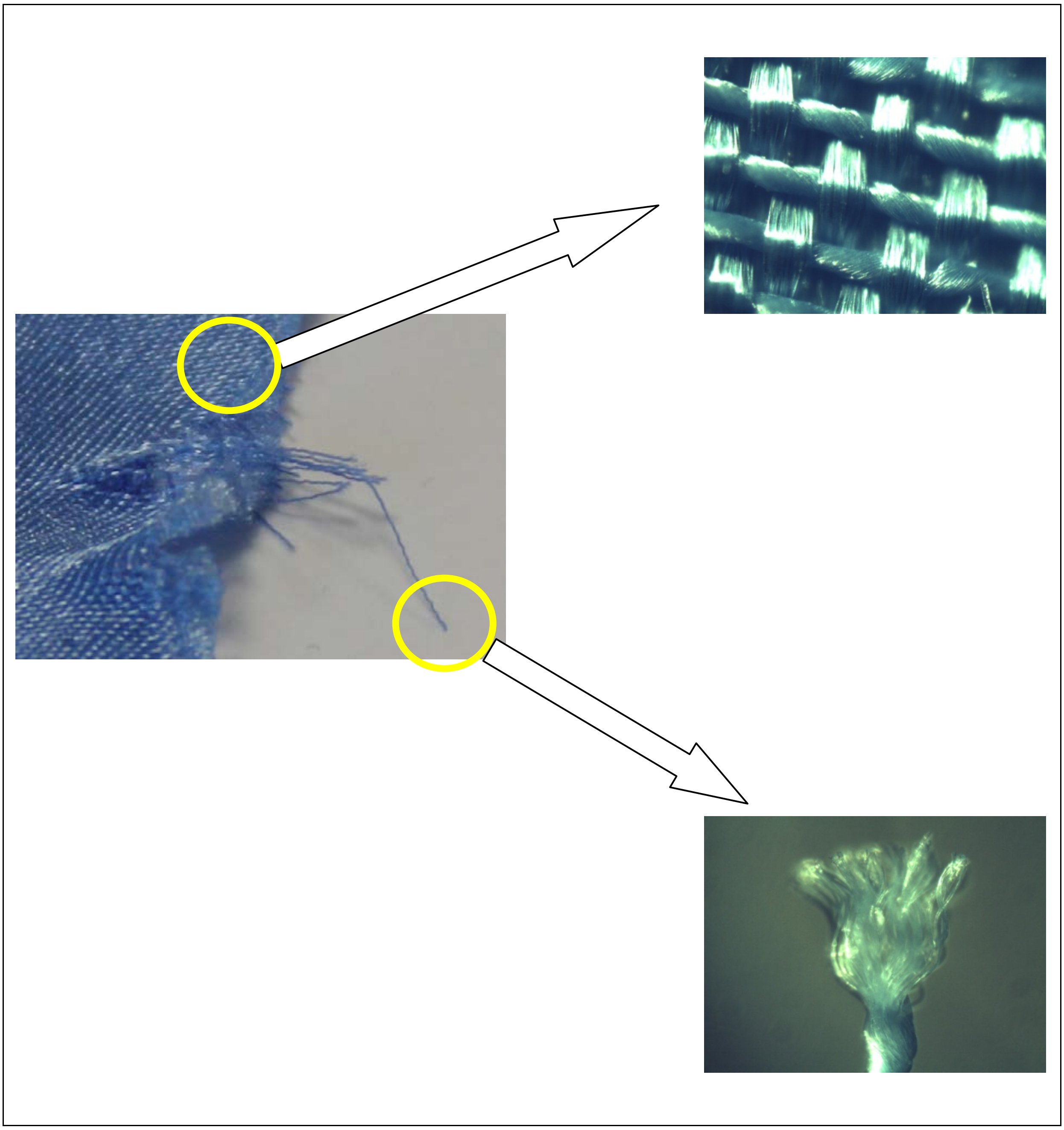
[14] Source (adapted from):
Wagner, Günter und Blank-Rothenburg, Helga (2001). Bei welcher Temperatur wird Wäsche hygienisch sauber - Wirksamkeit verschiedener Haushaltsreiniger auf ihre antibakterielle Wirkung. *Naturwissenschaften im Unterricht - Chemie,* 12(63), 51-52.

SUB UNIT 3:

Activity 3.1: Analyzing fibres

Examine pictures of different fibres made with regular camera and light microscope.

Compare the pictures of a polyester sample:



Compare the pictures of a polyamide jacket sample:

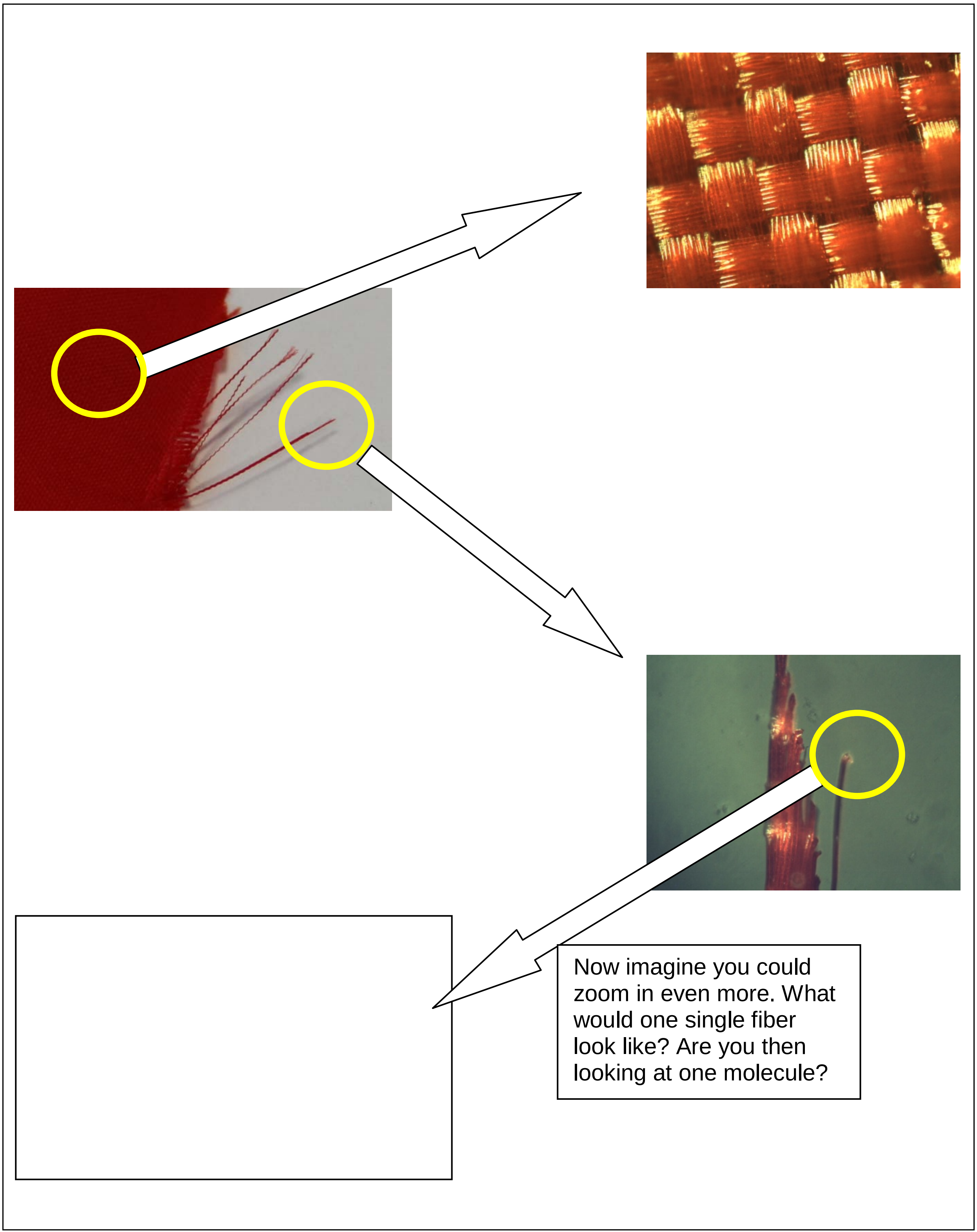
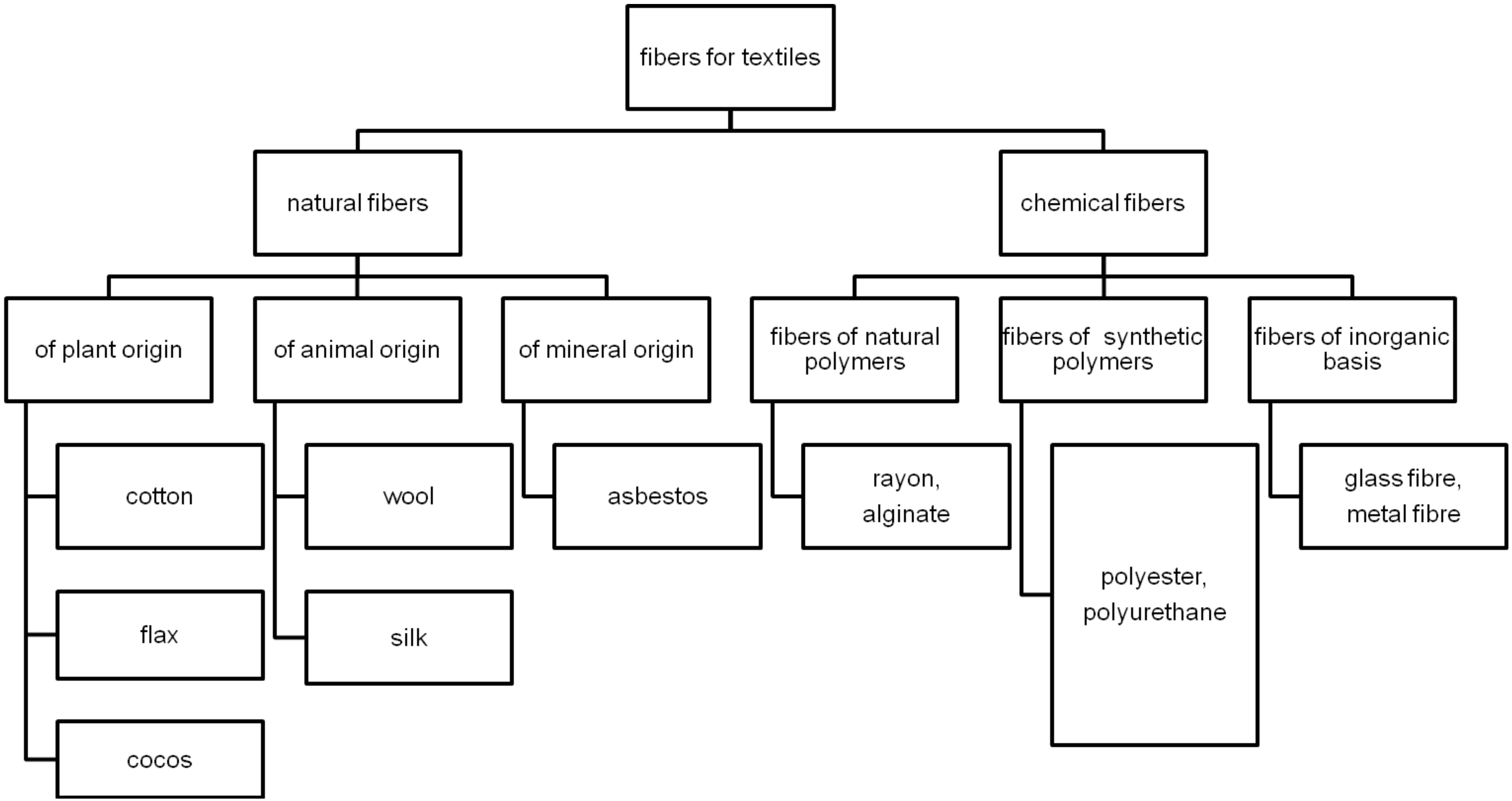


Figure 1: General classification of textile fibres



Activity 3.2: The history of fibres

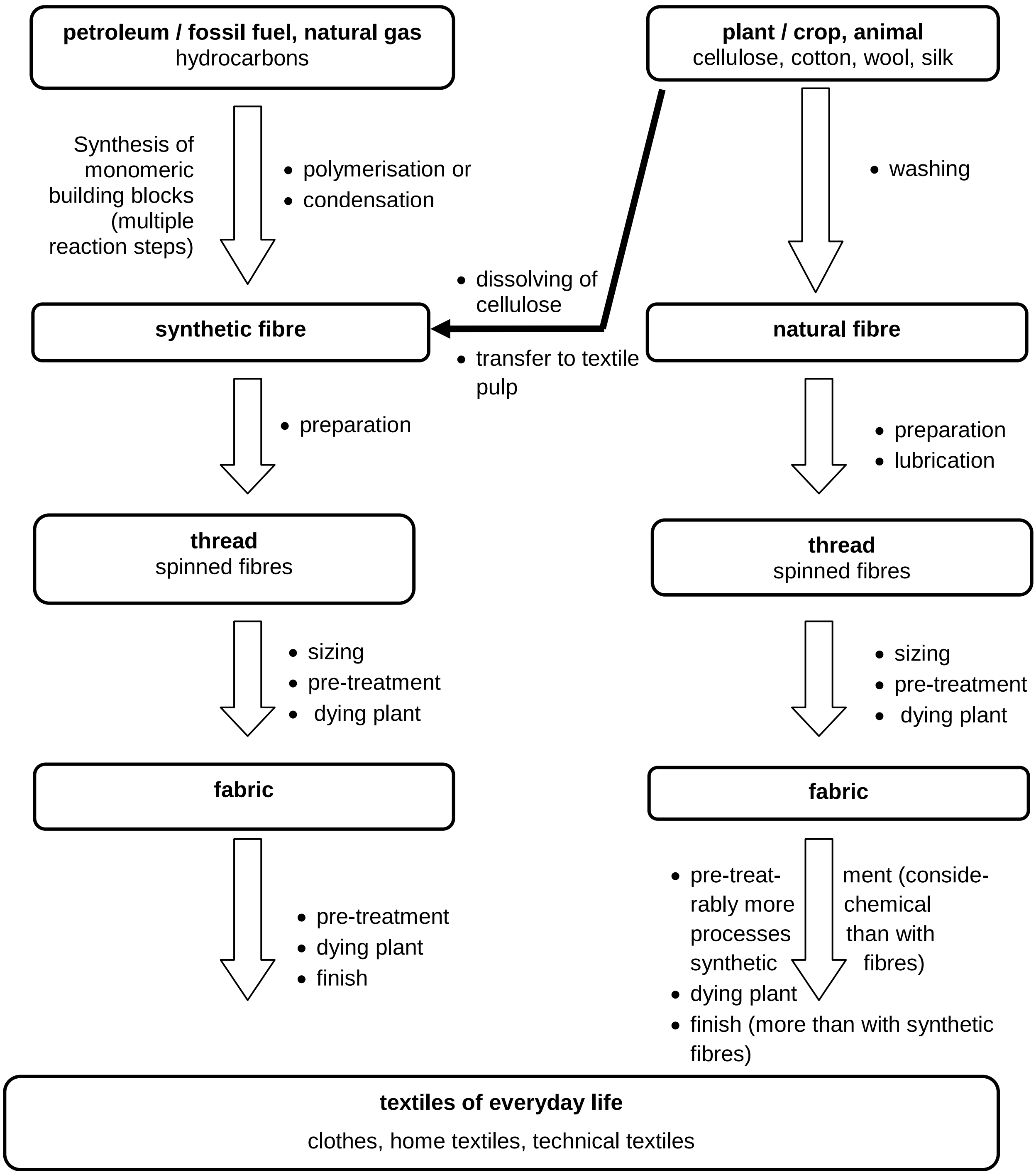
History of the development of synthetic fibres[15]

			Basic patent	
Type of fibre	Inventor	Patent No.	Application date	Start of production
Polyvinyl chloride	F. Klatte	DRP.281877	4.7.1913	1931
Polyvinyl alcohol	W. O. Herrmann and W. Haehnel	DRP.685048	11.3.1931	before 1935
Polyamide (PA 6.6)	W. H. Carothers	U.S.P.2.071.250/1	3.7.1931	1938
Polyethylene	E. W. Fawcett and co-workers	Brit. P. 471590	4.2.1936	1937
Polyvinylidene chloride	R. M. Wiley	U.S.P.2.160.931	1.7.1936	1940
Polyurethane	O. Bayer, H. Rinke and co-workers	DRP.728981	13.11.1937	1939
Polyamide (PA 6)	P. Schlack	DRP.748253	11.6.1938	1939
Polytetrafluoroethylene	R. J. Plunkett	U.S.P.2.230.654	1.7.1939	1954
Polyester	J. R. Whinfield and J. T. Dickson	Brit.P.578079	29.7.1941	1947
Acrylic fibres	H. Rein R. C. Houtz	DBP.915034 U.S.P.2.404.713	14.4.1942 17.6.1942	1943 1942
Polyamide (PA 11)	J. Zeltner and M. Genas	Frz.P.928265	21.4.1944	1948
Polyvinyl acetate	T. Tomonari and co-workers	DBP.932626	17.3.1951	1948
Polypropylene	G. Natta, P. Pino and G. Mazzanti	Ital. P.535712	8.6.1954	1959
Aramid fibres	DuPont	Belg.O.565266/8	1957	1962
Polylactic acid	DuPont	U.S.P.2.668.162	1954	n.a.

[15] Source (adapted from):
P.-A. Koch(2008). Faserstoff-Tabellen; IN Koslowski, Hans-J. (Hrsg). Chemiefaser-Lexikon: Begriffe - Zahlen – Handelsnamen. 12., erweiterte Aufl. Frankfurt am Main: Deutscher Fachverlag GmbH.

Activity 3.3: Research into the process of the production of textiles

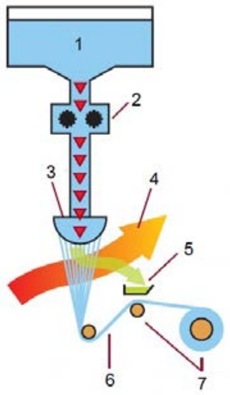
General way from raw material to fibre[16]



[16] Source (adapted from):
Fonds der Chemischen Industrie im Verband der Chemischen Industrie e.V. “Informationsserie TEXTILCHEMIE“. page 12.

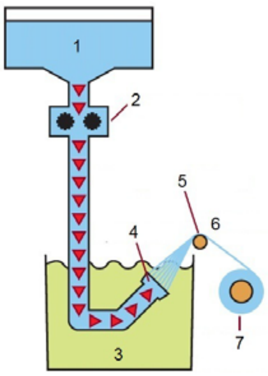
Worksheet 6: The spinning process[17]

Tasks:
1) Find out about different spinning processes to obtain synthetic fibres.
2) Describe the processes and find out which process can be used for which synthetic fibre.



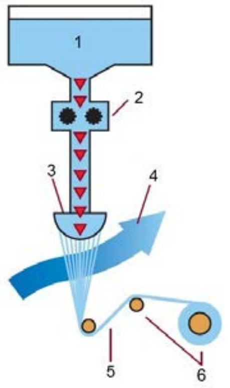
<u>The dry spinning process</u>

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______



<u>The wet spinning process</u>

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______



<u>The melt spinning process</u>

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______

[17] Source of figures:
Fonds der Chemischen Industrie im Verband der Chemischen Industrie e.V. "Informationsserie TEXTILCHEMIE: Arbeitsblätter". page 3.

Solution to Worksheet 6: The spinning process[18]

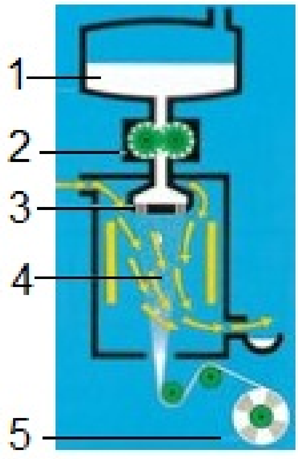
Production processes of textile fibres – the spinning process

There are several methods for making semi-synthetic fibres. Research for example the methods for making acetate silk or rayon, copper yarn or viscose. There exist also several different methods of spinning, i.e. to twist fibres together to make yarn: the dry spinning process, the wet spinning process and the melt spinning process (for more information see: http://www.ivc-ev.de/live/index.php?page_id=58**).**

The spinning process

Synthetic fibres can be obtained by different manufacturing processes. Endless yarns called filaments are produced from spin mass. This is pressed through a spinneret. A spinneret can be compared to a bathroom shower head as the spinnable matter (liquid or viscous) must be carefully filtered and is pressed through these from one to several hundred tiny holes or rather openings. When the filaments exit these holes, the liquid polymer is in the spinning process. Then it is first converted to a rubbery state (process of extrusion) and then solidified (process of solidification).

Wet spinning, dry spinning, melt spinning, and gel spinning are the four processes of spinning filaments of manufactured fibres.



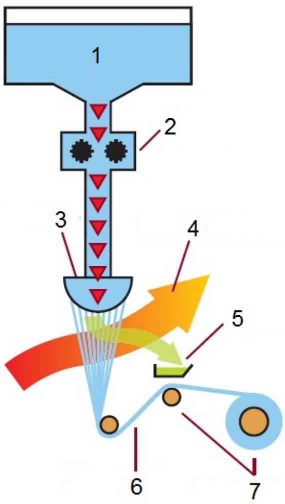
The spinning process
(common basic processes)

1. a container holds the spinn mass
2. the spin mass is dosed by a spin pump
3. the spinneret
4. the filament is formed in a medium
   Drawing the filaments may impart strength as drawing pulls the molecular chains together and orients them along the fiber axis which creates a stronger yarn.
5. the filaments are gathered to a filament yarn and spooled by a special device

The dry-spinning process

A container holds the spinn mass (1) which is soluted in an organic solvent. The spin mass is dosed by a spin pump (2) and exits the spinneret (3) into a spinning duct. By evaporating the solvent in a stream of carefully blown in (warm) air or inert gas (4) the solidification of the polymer/filaments is achieved. The filaments are not allowed to touch each other in order not to stick together. The solvent is recaptured (5) and used again. Then the drawing/ stretching of the filaments takes place (6). Finally, they are wound up (7).

This process is applied to produce fibres of acetate, triacetate, acrylic, modacrylic, PBI, spandex, and vinyon.

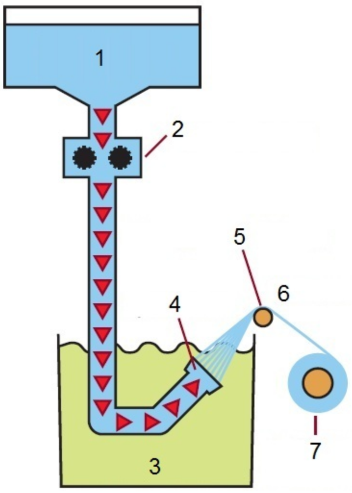


The wet spinning process

In the wet spinning process, which is the oldest used process, the solution is extruded/ pressed directly into the precipitation liquid.

A container holds the fibre-forming substance (spin mass) which is dissolved in a solvent (1). The spin mass is dosed by a spin pump (2). The spinnerets (4) are submerged in a chemical bath (3). When the filaments emerge from the spinnerets, they precipitate from solution and solidify. This is due to a bath which causes the filaments to coagulate. They are pulled towards the top (5). As they are still soft, the drawing/ stretching of the filaments takes place (6). By modifying the stretching, the fibres can be changed according to their specific purpose regarding their stiffness/ resistance and stretching/expanding behaviour. Before they are finally wound up (7) they need to be cleaned from chemicals.

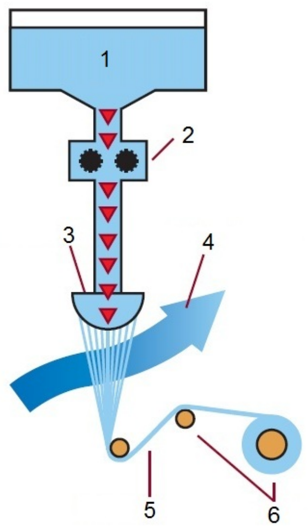
By this process acrylic, aramid, modacrylic, rayon, and spandex can be produced.



The melt spinning process

The melt spinning process is a simple and economic process. In melt spinning, the fibrous raw material needs to be meltable (must not decompose at its melting temperature). The fiber-forming substance is heated and melts (1) before being filtered and dosed by a spin pump (2). Then the extrusion through the spinneret (3) takes place – the melt is pressed through it. The rays of the spin mass flow into a duct several meters high to solidify by cooling via a uniform cold air stream (4). They have to solidify rapidly in order to resist the haul-off speed. Then the drawing/ stretching of the filaments takes place (5). Finally, they are wound up (6).

In this manner, fibres such as nylon, polyester, olefin, saran (polymers made from vinylidene chloride along with other monomers), and polyphenylene sulfide (PPS) (sulfar) are produced.



The gel spinning process

In order to obtain high strength or other special fibre properties this process is used. During the step of extrusion, the fibrous material (polymer) is not in a true liquid state as the polymer chains are bound together at various points in liquid crystal form (in a true solution they would be completely separated). In this process the filaments first pass through air and are then cooled further in a liquid bath. The filaments produced by this method have strong inter-molecular forces which can increase the tensile strength of the fibers. The emerging filaments exhibit a high degree of orientation relative to each other which further enhances strength. In this manner high-strength aramid or polyethylene fibres are produced.

[18] Sources:

- Fonds der Chemischen Industrie im Verband der Chemischen Industrie e.V. "Informationsserie TEXTILCHEMIE: Arbeitsblätter". page 24. http://fonds.vci.de/template_downloads/tmp_fonds.vci.de/119988FCI_Textilchemie_Textheft_20070301.pdf?DokNr=119988&p=111
- Industrievereinigung Chemiefaser e.V. (Herausgeber): Chemiefasern: Von der Herstellung bis zum Einsatz. Frankfurt/Main. Kapitel 6.1 „Fasern nach Maß". English version available see "Man-Made Fibres – The Way From Production To Use" p. 15. http://www.ivc-ev.de/live/index.php?page_id=92
- Manufacturing: Synthetic and Cellulosic Fiber Formation Technology. American Fiber Manufacturers Association / Fiber Economics Bureau. 2012. Zugriff: 28.02.2012. http://www.afma.org/f-tutor/techpag.htm

Activity 3.4: Properties of different fibres

Collect different clothes samples, made of different fibres.

Plan experiments investigating the following properties of your textile samples (e.g. wool, silk, cotton, rayon...):

- Permeability regarding air (with pressure)
- Permeability regarding water (jet of water and water drops)
- Permeability regarding steam
- Amount of water absorption
- Insulating properties
- Behaviour when heated

Activity 3.5.1: Innovation in the clothing industry

Material:
Worksheet 7

Tasks:

1. Rate the arguments into those in favour of using innovations in the clothing industry and those against it.
2. Find out about the underlying principle. Explain it. You may paint a model to explain the steps. (Search the internet for material and information)
3. List further pros and cons regarding the application/ usage of such chemicals or silver. Are there alternatives? Evaluate this new innovation. Take into consideration these various aspects regarding this topic.

Worksheet 7: innovation in the clothing industry

New high-tech textiles kill germs. Thus, body-odour is inhibited as the propagation of bacteria is inhibited.

There are different methods that are used to produce antimicrobial textiles. Some manufacturers use chemical additives such as quaternary ammonium salts, different kinds of the biopolymer (polysaccharide) Chitosan, or the antibacterial and antifungal as well as preserving agent Triclosan (not used anymore due to possible harmful impact to health).

Some manufacturers use silver which is weaved into the textiles in the form of fine threads or the fibres are interspersed by silver particles. Silver ions kill the bacteria which has an antimicrobial effect. Products contain small amounts of the metal, in the form of nanoparticles that release ions slowly over time.

Tests regarding the loss of silver during washing showed large variations in the amount of silver released in the first washing. Most of the silver was in the form of coarse particles of larger than 450 nanometers. This suggests that mechanical stress in the washing machine was responsible for most of the release.

There are concerns about antimicrobial textiles that the additives (e.g. silver ions) may harm the natural skin flora over a longer period of time. It is important to know if the antibacterial silver, e.g. in sportswear, harms the skin of healthy people as there are billions of bacteria and fungi on the skin which play an important role in the body's own infection defence and keep possibly pathogenic germs under control.

Silver can be very effective regarding neurodermatitis as it kills bacteria. Studies showed that by wearing antimicrobial textiles, the skin appearance improved in only a few weeks. The reason for that is that silver ions attack the staphylococcus aureus, a germ typically found with this skin disease.

Activity 3.6: Keeping textiles clean

Worksheet 8: Research project

Task:

find out about the following:

a) What are your clothes made of?
b) What all can you do with your clothes in order to get them clean? Consult the care label for details. For information on what the icons mean, look for information in books or the internet.

For a list of care icons (there are icons for washing, chemical cleaning, ironing, drying and bleaching), see for example:
http://www.textileaffairs.com/docs%5Ccommon-050608.pdf

Worksheet 9: How bleaching agents work[21]

Besides surfactants, which are used as washing active substances, heavy-duty detergents often include bleaching agents. These remove dirt by means of oxidation processes. Bleaching agents were not always present in laundry detergents. At one time, laundry used to be spread out on the grass to be bleached by natural ultraviolet radiation from the sun. During the course of time, as laundry detergents underwent further development, a variety of bleaching agents came to be used.

Tasks

1) Find out about the various bleaching agents and draw up an overview of the bleaching agents you think would be suitable for inclusion in laundry detergents, and the ones which would not. Give reasons for your choices.
2) After consulting your teacher, carry out experiments to show the effects of various bleaching agents.

[21] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 10: The development of laundry detergents – from laboratory to production scale[22]

You work in the laboratory of a laundry detergent manufacturer. You would like to develop a new laundry detergent and you have to give your colleagues an overview of the properties your new product should have and what ingredients it should contain.

Tasks

1) Decide first of all which type of laundry detergent you want to produce and what properties it should have (e.g. particularly good environmental compatibility, an attractive price, no fragrances, etc.). You can choose from three detergent types: heavy-duty detergents, detergents for colored fabrics, detergents for wool and silk.
2) **Material 1** contains standard compositions for the three laundry detergent types and **Material 2** contains a choice of laundry detergent ingredients with their corresponding identification numbers (CAS no.). Use this material to gather information on the Internet about the criteria you have drawn up for the ingredients of your laundry detergent type and create a table. The following Internet sites may be helpful:

Wikipedia Encyclopedia	**http://en.wikipedia.org/wiki/Main_Page**
Database on hazardous substances	**http://www.dguv.de/bgia/en/gestis/index.jsp**
Costumer information on cleaning products	**http://uk.cleanright.eu/**
Raw material prices, e.g. Sigma-Aldrich	**www.sigmaaldrich.com** (Registration site)

3) Briefly describe the characteristic ingredients your laundry detergent should have. Remember that industrial production is a very large-scale operation. Give reasons for your decision. Also relate briefly whether there are any ingredients that should NOT be in the laundry detergent you develop.

[22] Worksheet and relating Materials 1-2 are taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Material 1

Standard compositions of laundry detergents

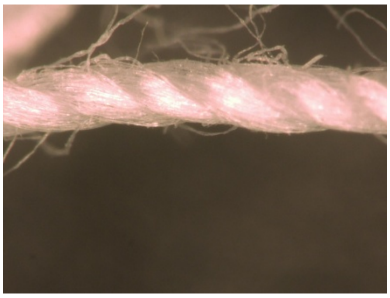
Laundry detergents	Ingredients < 5%	Ingredients 5% to 15%	Ingredients 15% to 30%	Ingredients > 30%	Other ingredients
Heavy-duty laundry detergents	Nonionic surfactants Soap Polycarboxylates Phosphonates Aliphatic hydrocarbons	Anionic surfactants	Oxygen-based bleaching agents Zeolites		Enzymes (cellulase, lipase, protease) Optical brighteners Fragrances
Detergents for colored fabrics	Soap Polycarboxylates Phosphonates	Nonionic surfactants	Anionic surfactants	Zeolites	Enzymes (cellulase, lipase, protease) Fragrances Dye transfer inhibitors
Laundry detergents for wool and silk	Soap Polycarboxylates Nonionic surfactants	Anionic surfactants Zeolites			Care Balsam Fragrances Auxiliaries Dye transfer inhibitors

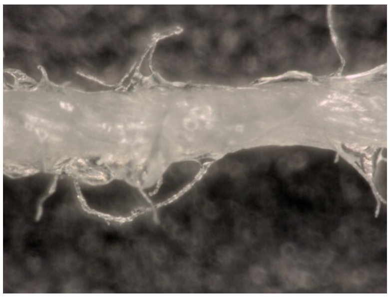
Material 2

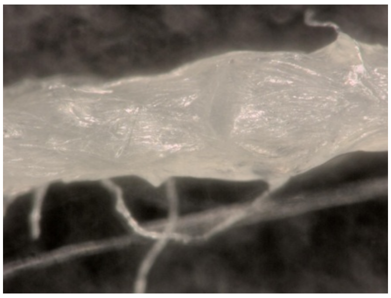
Name of the laundry detergent ingredient	CAS no.
Washing active substances	
Anionic surfactants	
Soap	8052-48-0
Linear alkylbenzene sulfonates (LAS)	27176-87-0
Branched alkylbenzene sulfonates (TPS)	11067-82-6
□-Olefin sulfonates	
Nonionic surfactants	
Alcohol alkoxylates (EO/PO)	69013-18-9
Alkyl polyglycosides (APG)	
Softeners/Builders	
Soda ash (Na_2CO_3)	497-19-8
Nitrilotriacetic acid (NTA)	139-13-9
EDTA	60-00-4
Sodium tripolyphosphate	7758-29-4
Zeolite A	1318-02-1
Polycarboxylates	
Phosphonates, e.g. HEDP	2809-21-4
Bleaching agents	
Sodium hypochlorite	7681-52-9
N,N,N',N'-Tetraacetylethylene diamine (TAED)	10543-57-4
Sodium perborate	7632-04-4
Sodium percarbonate	15630-89-4
Enzymes, e.g. lipase, protease and cellulase	
Foam regulators	
Fatty acid amides	124-26-5
Cocoamidopropyl betaine	61789-40-0
Optical brighteners	
Stilben derivatives	16090-02-1
Naphthalene benzoxazoles	5089-22-5
Perfumes	
Sandalwood oil	8006-87-9
Linalool	78-70-6
Citronellol	106-22-9
Musk xylene	81-15-2
Dye transfer inhibitors, e.g. polyvinylpyrrolidone PVP	9003-39-8
Antisoiling agents, e.g. PET/POET polymers	
Antiredeposition agents, e.g. carboxymethyl cellulose	9000-11-7
Fillers, e.g. Na_2SO_4	7757-82-6
Colorants	
Corrosion inhibitors, e.g. sodium silicate (Na_2SiO_3)	6834-92-0

Worksheet 11: Behaviour of fibres during washing process

1. Look at the following pictures (same fibre with different enlargements, taken by Kirsten Fischmann at Henkel facility) and comment on them.


Cotton fibre


Cotton fibre with Persil Gold Universal Gel


Cotton fibre with Persil Gold Universal Gel

2. Reserach in school textbooks or on the internet, how dirt is removed from fabric on a submicroscopic level.
3. Carry out the experiment as described in Worksheet 11a.

Worksheet 11a: Behaviour of fibres/textiles in the washing process

Apparatus and materials

- petri dishes and small beakers or yoghurt cup (depends on the number of laundry detergents and the concentration of solutions you like to test)
- pipettes and spatula (one for every detergent, depends on the viscosity)
- pieces of cloth/ threads of different fibres (wool, cotton, polyester, polyamide, viscose); multiplied by the number of detergent (and concentration, if you want to test several)
- tap water
- different laundry detergents (e.g. Persil-Universal-Powder; Persi-Universal-Gel; Perwoll-care for fine fabrics; Persil-Color-Gel; Perwoll-Powder for Wool and Silk; citric acid; washing soap)
- beakers to mix detergent and water
- pH meter
- stop watch
- scissors
- pair of tweezers
- microscope
- heating panel
- glass rod for stirring

Safety

- Wear your safety goggles!

Procedure

- Measure the pH value of tap water and each laundry detergent and solution.
- Prepare solutions of water and laundry detergent in beakers. Prepare solutions of different concentrations for each detergent. (for example, in one beaker add 50 g or 50 ml of the laundry detergent and about 250 ml of tap water and in another beaker prepare a higher concentration the laundry detergent) Label the beakers with name of detergent and concentration.
- Measure the pH value of each laundry detergent solution.
- Fill each solution in X (X = number of textile samples) petri dishes or small beakers.
- Then add a tiny piece of cloth and/or some fibres in one petri dish.
- Heat the solution up to 60°C on heating panels and stir the solution to simulate the washing process.
- Analyse the fibres after 5, 30, and 60 minutes under the microscope.

Disposal

- Take the pieces of cloth/ some fibres/threads out of the petri dishes with a pair of tweezers and put them into the dustbin.
- As these are solutions of laundry detergents, pour them down the sink.

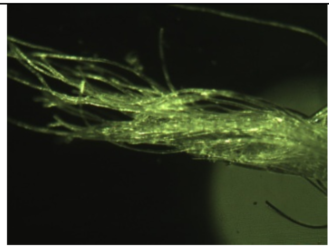
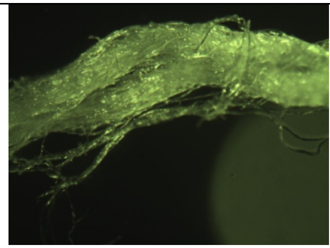
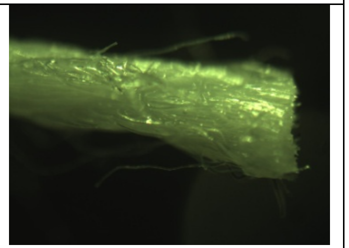
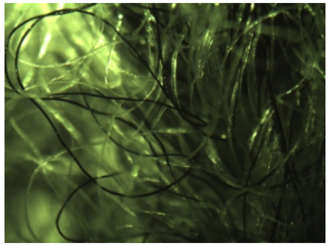
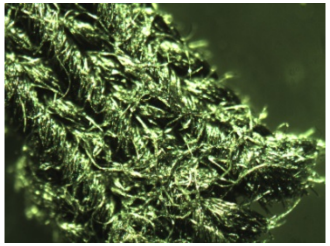
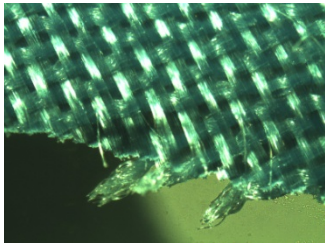
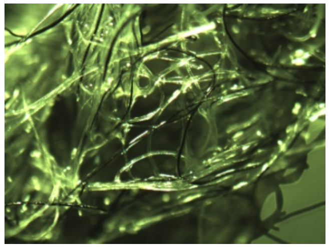
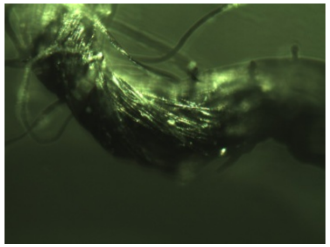
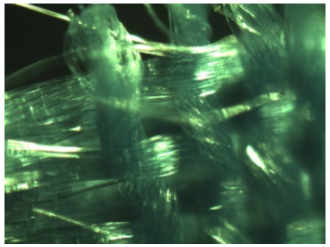
Tasks:

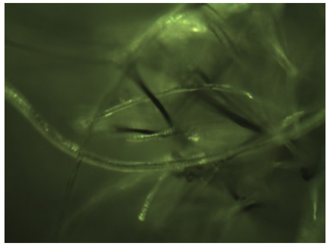
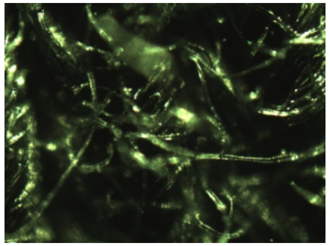
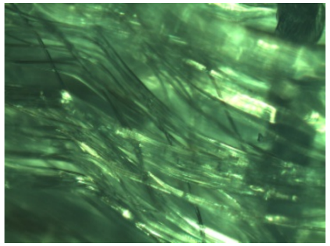
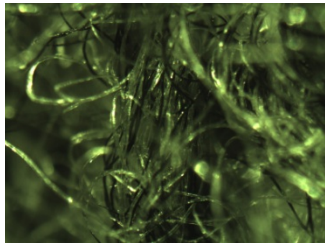
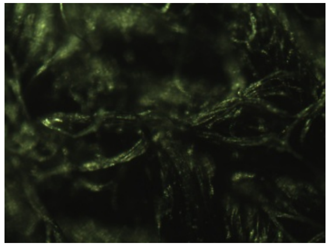
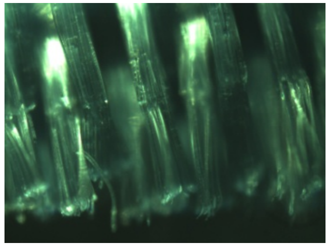
1. Carry out the experiments in teams.
2. Fill in the table in Material 3 with a description of how the fibres look under the microscope.

Material 3: Analysis of cloth/fibre samples in different washing solutions

Detergent	soaking time and temperature	concentration		pH value		natural fibres				synthetic fibres					
						wool		cotton		polyester		polyamide		viscose	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II
all-purpose detergent	5 min.														
	30 min.														
	60 min.														
mild detergent	5 min.														
	30 min.														
	60 min.														
detergent for bright colors	5 min.														
	30 min.														
	60 min.														
special detergent: for woollen fabrics	5 min.														
	30 min.														
	60 min.														
washing soap	5 min.														
	30 min.														
	60 min.														
citric acid	5 min.														
	30 min.														
	60 min.														

Material 3: Possible solution - Analysis of the fibre samples in different washing solutions

				Describe how the fibre look like under the microscope:		
				natural fibres		**synthetic fibre**
Laundry detergent	**soaking time and temperature**	**concentration (detergent in g or ml / H_20 in ml)**	**pH value**	**wool**	**cotton**	**polyester**
All-purpose detergent • Persil-Universal-Powder	90 min. 40°C	5 g in 100 ml H_20	10,74			
Mild detergent • Perwoll – care for fine fabrics (liquid)	110 min. 40°C	5 ml in 250 ml H_20	**7,97**			
soapsuds • e.g. Fa Bar Soap Vitalizing Aqua	180 min. 40°C	**3 g in** 250 ml H_20	**9,33**			

• washing soda	180 min. 40°C	**2 EL in 250** ml H_20	**11,26**			
acidic solution • vinegar cleaner	180 min. 40°C	**5 ml in 250** ml H_20	**3,75**			

Material 4: Differences between laundry detergents

	all-purpose detergent (solid/ powder)	all-purpose detergent (liquid)	mild detergent	detergent for bright colors	detergent for special fabrics e.g. detergent for wool and silk	fabric softener
examples of Henkel AG & Co. KGaA products	Persil Universal, Weißer Riese, Spee als Pulver, Megaperls®, Tabs		Persil, Weißer Riese, Spee als Gel, Spee Feinwäsche, Perwoll Black für Schwarzes und Dunkles, Perwoll Sport für Synthetics	Persil Color, Weißer Riese Color, Spee Color als Pulver, Megaperls®, Tabs, Gel	Perwoll Wolle & Seide Perwoll Pflege für Feines (liquid)*	Vernel
anionic surfactants	✓	✓	✗	✓	✓	✗
non-ionic surfactants	✓	✓	✓	✓	✓	✗
cationic surfactants	✗	✗	✗	✗ (✓)	✗	✓
softener	✓	✓	✓	✓	✓	✗
bleaching agent	✓	✗	✗	✗	✗	✗
enzymes	✓	✓	✓	✓	✗	✗
optical brighteners	✓	✓	✗	✗	✗	✗

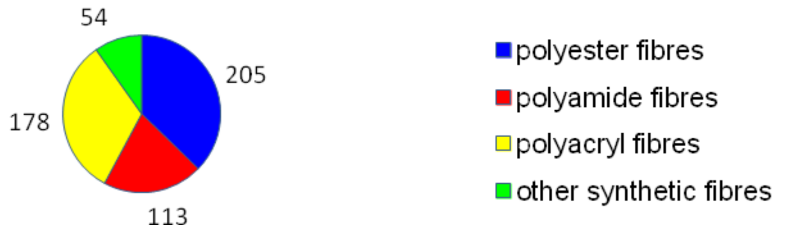
[23] Sources:

- http://dblay.de/einblicke/wasch/arten
- Richtig Waschen: Informationen rund ums Waschen – Spülen – Reinigen. Jens Gebhard, Christa Wolf, Kerstin Ochs. Henkel AG & Co. KGaA. Redaktion: Consumer Relations. Düsseldorf, 2008. http://www.henkel.de/de/content_data/95757_richtigwaschen_080723.pdf
- (Flyer) Textilien richtig waschen – Werte erhalten. Forum Waschen c/o. Industrieverband Körperpflege- und Waschmittel e.V. (IKW). Frankfurt am Main. 2011. http://www.ikw.org/pdf/broschueren/IKW_FB_RichtigWaschen_web.pdf

Activity 3.7: Economic view on textiles

Production of chemical fibres in Germany 2010[24]

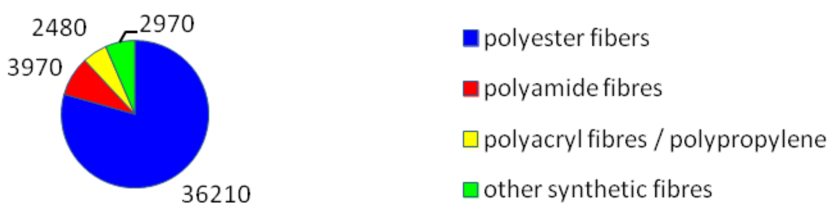
in 1000 tons



synthetic fibres, total	550
cellulose fibres	201
chemical fibres, total	751

World production of chemical fibres 2010

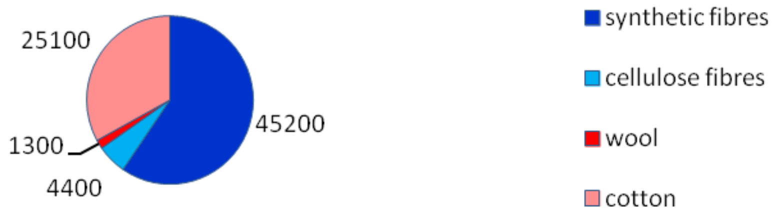
in 1000 tons



synthetic fibres, total	45.630
cellulose fibres	3.970
chemical fibres, total	49.600

World production of textile fibres 2010

in 1000 tons



[24] Source:
Industrievereinigung Chemiefaser e.V. http://www.ivc-ev.de/live/index.php?page_id=43

Activity 3.8: Ecological view on textile care

Worksheet 12: The influence of temperature on wash performance[25]

Imagine you have a cocoa stain on your white T-shirt! Is it true that the higher the wash temperature is, the more easily the stain can be removed? To find out, you will be given cocoa-stained cotton cloths to wash at different temperatures.

Tasks

1) Plan an experiment, with which you can test wash performance at different temperatures. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record the wash result.
3) At which temperatures did you obtain the best wash result? Why is this?
4) Investigate how much energy you could save by washing at 30°C or 40°C instead of 60°C. Calculate the saving in electricity costs. Which other electrical appliances could you run with the saved energy?

[25] Worksheet taken from:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 13: Improving wash performance by adding stain remover[26]

The chosen wash temperature is one of the factors that influence how good the wash performance is. In this experiment you will now investigate how the addition of stain remover affects the wash performance. To do this you will be given cocoa-stained cotton cloths, which you will wash with laundry detergent, stain remover and a combination of laundry detergent and stain remover.

Tasks

1) Plan a series of experiments with which you can investigate the effect of stain remover on wash performance. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record the wash result.
3) With which experiment did you obtain the best wash result? Why is this?

[26] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 14: The effect of laundry detergent dosage and water hardness on wash performance[27]

You have probably seen the advice shown below on a packet of laundry detergent at home:

4/5 Kg	SOFT WATER	80ml	120ml	200ml
	MEDIUM WATER	120ml	160ml	240ml
	HARD WATER	160ml	200ml	280ml

This shows the recommended dosage of laundry detergent for different degrees of soiling and water hardness. The experiment investigates the effect of the detergent dosage and the hardness of the water on the wash performance. This is done by washing pieces of cocoa-stained cloth using different dosages of laundry detergent.

Tasks

1) Plan a series of experiments with which you can investigate the effect of the laundry detergent dosage and the hardness of the water on the wash performance. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record the wash result.
3) With which dosage did you obtain the best wash result? Why is this? Take the hardness of the water into account.
   (Note: You can find an overview of water hardness on the Internet, e.g. by looking up the region's waterworks.)

[27] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 15: The influence of laundry detergents on the growth of cress plants[28]

Wastewater from households (for example from the washing machine) is thoroughly cleaned in sewage treatment plants so that it can be discharged into surface water. What would happen if we discharged our wastewater into the environment without subjecting it to any sort of treatment beforehand? This experiment shows the influence of a laundry detergent on the growth of cress plants. The wash water represents the wastewater, and the cress plants represent the environment.

Tasks

1) Devise a series of experiments with which you can investigate the effect of the laundry detergent on the growth of cress plants. Use different concentrations of the laundry detergent. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record your observations. How did the cress change under the influence of the laundry detergent?
3) Plot your results on a graph.

[28] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 16: Biodegradability of surfactants – Part 1[29]

Each year, about **250,000 metric tons** of surfactants are used in households, trade and industry in the Federal Republic of Germany. Most of them – about 64 percent – are ingredients of laundry detergents and household cleaners. They are also used in cosmetics and pharmaceuticals, textile and leather auxiliaries and in numerous other sectors. Anionic surfactants are the most widely used (136,000 metric tons each year), followed by the nonionic surfactants (approximately 97,000 metric tons).

The surfactants used in households, e.g. to wash laundry, enter the drains unchanged in the wash liquid. High concentrations of surfactants are toxic to many aquatic life forms (e.g. fish and algae). For reasons of environmental compatibility, it is therefore very important that these surfactants are rapidly removed from the environment, e.g. by undergoing **biodegradation**.

There are two stages of surfactant biodegradation: **primary** and **ultimate**.

When primary biodegradation occurs, the basic chemical structure of the surfactants remains largely unchanged, but they lose their characteristic ability to dislodge dirt. They also become less toxic to organisms that live in water, and form less foam.

As biodegradation proceeds, the surfactants are broken down into ever smaller and simpler units. These changes are caused by the metabolic processes that take place in microorganisms that use organic substances as food. Finally the surfactants are converted into mineralization products such as carbon dioxide (CO_2), water (H_2O) and salts, together with biomass (bacterial cell material). The biomass is formed from small C-H units, and its formation is the reason why, strictly speaking, substances never undergo 100% ultimate biodegradation.

In 1973, Europe's first piece of legislation regulating the ingredients of laundry detergents and household cleaners came into force. This was the Detergent Directive. It stipulated that anionic and nonionic surfactants in laundry detergents and household cleaners would have to have a primary biodegradability of at least 80%. During the following years, however, the consumption of laundry detergents and household cleaners continued to increase and the required primary biodegradability proved to be no longer adequate. The new so called EU Detergent Regulation of 2004 therefore stipulated that all washing-active surfactants in laundry detergents and household cleaners must be ultimately biodegradable.

Tests of primary biodegradability include the **OECD Confirmatory Test** and the **OECD Screening Test**. Tests of the ultimate biodegradability of organic compounds include the **Closed Bottle Test (OECD 301 D)** and the **Coupled Units Test (OECD 303 A)**.

Tasks

1) Explain the difference between primary and ultimate biodegradation of surfactants. Why is it not possible to achieve 100% ultimate biodegradation?
2) In the late 1950s, mountains of foam could be observed on surface waters. These were caused by the surfactants in the laundry detergents that were in use at that time. Explain how foam came to be formed on surface waters.
3) Search the Internet for information about OECD test methods. Briefly describe one test for primary biodegradation and one for ultimate biodegradation.

[29] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 17: Biodegradability of surfactants – Part 2[30]

Most of the ingredients of laundry detergents pass into sewage treatment plants with the wastewater. There they either undergo biodegradation or are removed by other processes before the cleaned wastewater is discharged into surface waters. If small amounts of ingredients, e.g. surfactants, do manage to enter the environment, nature is not completely defenseless, as some natural organisms are able to break down surfactants and other chemicals. This experiment shows what happens when small amounts of laundry detergents enter a river or lake.

Tasks

1) Plan an experiment, with which you can investigate the biodegradability of surfactants in rivers and lakes. Make a sketch of the experiment first, and then briefly write down what you are going to do.
2) Carry out your experiment and record your observations. Find explanations for what you observed.

[30] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 18: Biodegradability of surfactants – Part 3[31]

Since the mid-1950s, modern surfactants were used in large quantities in laundry detergents and household cleaners. Tetrapropylenebenzene sulfonate (TPS) was the first poorly biodegradable surfactant to be used. A visible sign of this was the mountains of foam on watercourses (Fig. 1).

Fig. 1: Mountains of foam on surface waters – caused by poorly biodegradable surfactants in detergents

The detergent industry responded by starting to develop and introduce readily biodegradable surfactants. Between 1961 and 1964, TPS was gradually replaced in the West Germany by linear alkylbenzene sulfonates (LAS). Moreover, the Henkel company measured the surfactant load in the river Rhine at two-weekly intervals. The results were made available to scientists, politicians and supervisory bodies, and were published annually. In the 1970s, the municipal sewage plants were also upgraded.

Tasks

Material 5 shows an overview of laundry detergent consumption in Germany from 1960 onward, and an overview of the surfactant loads in the river Rhine near Düsseldorf from 1958 to 2007.

1) Describe the course of the two graphs.
2) How can the graph of the surfactant load over time be explained in relation to the use of surfactants in laundry detergents?

[31] Worksheet and relating Material 5 are taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Material 5

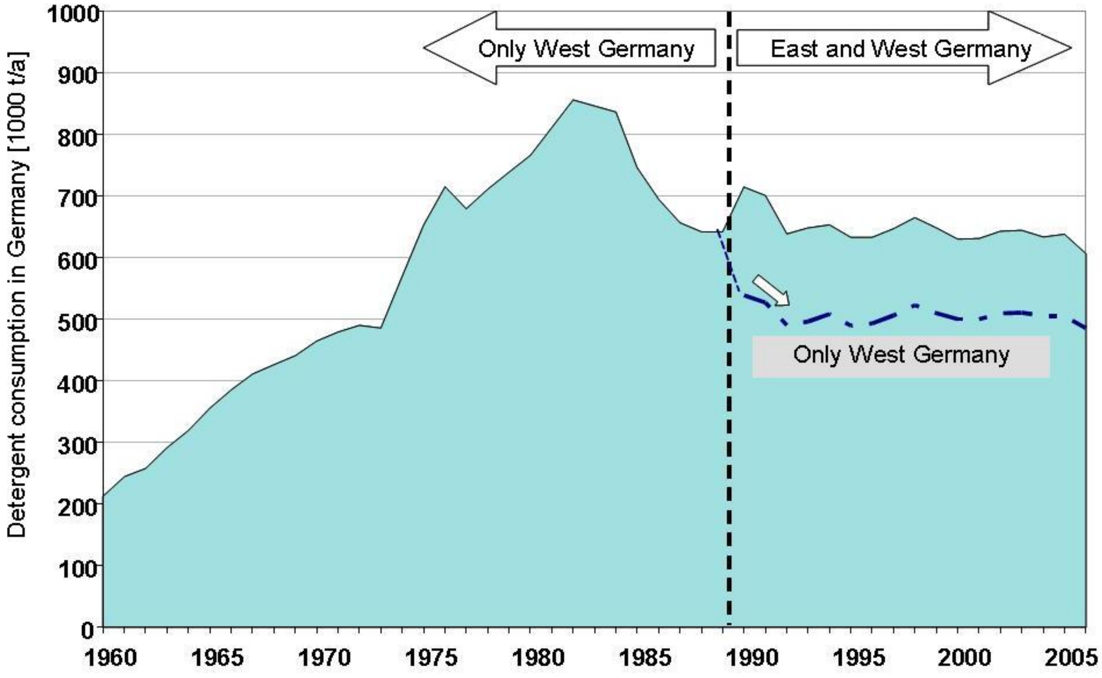


Fig. 1: Laundry detergent consumption in Germany

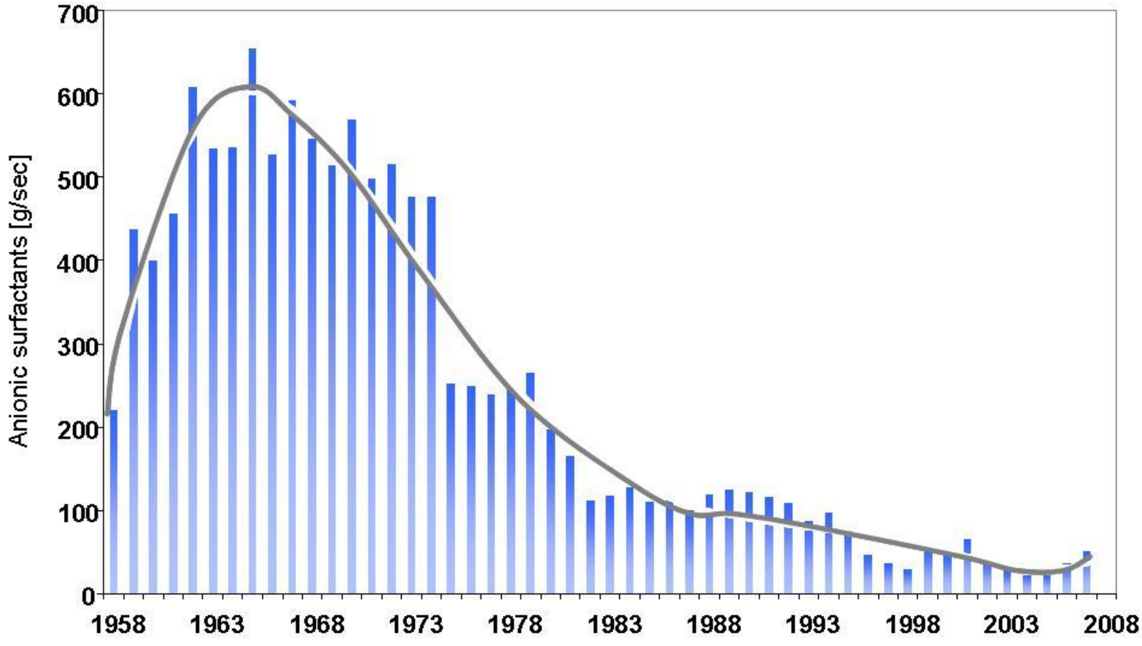


Fig. 2: Surfactant loads (median values) in the river Rhine near Düsseldorf (1958 – 2007)

Worksheet 19: Biodegradability of surfactants – Part 4[32]

The surfactant tetrapropylenebenzene sulfonate (TPS), which is poorly biodegradable, was phased out in West Germany between 1961 and 1964, and was replaced by surfactants known as linear alkylbenzene sulfonates (LAS).

The following diagrams show the structural formulas of TPS and a LAS:

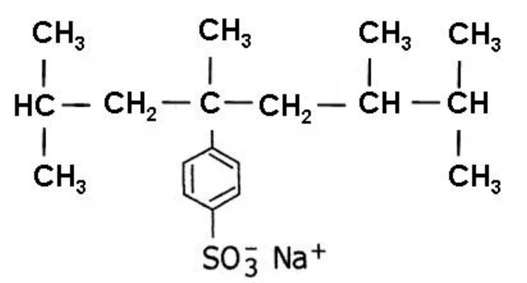


Figure 1: Tetrapropylenebenzene sulfonate (TPS)

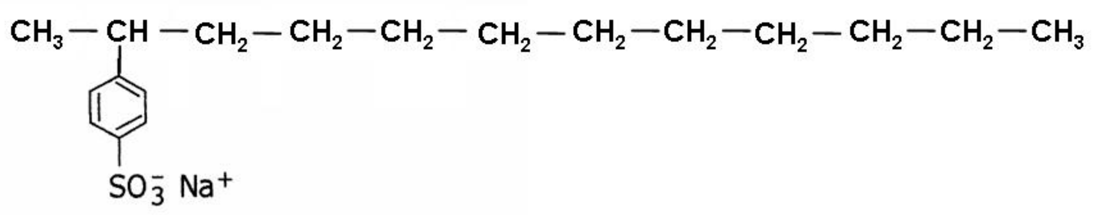


Figure 2: 2-Dodecylbenzene sulfonate (a LAS)

Task

What might the reason be for the poorer biodegradability of TPS relative to LAS?

Remember that the surfactants are broken down in surface waters by microorganisms.

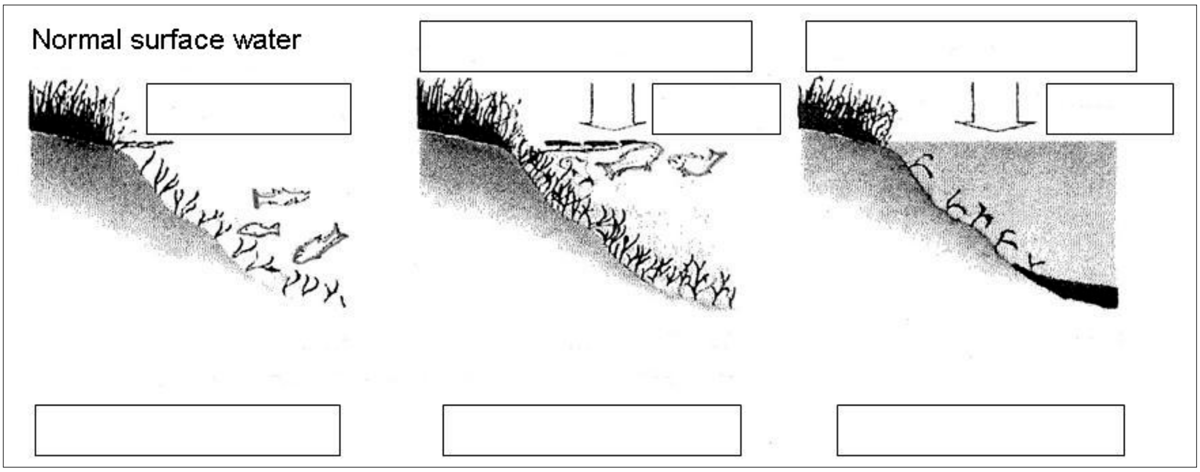
[32] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheet 20: Ecological impacts of the phosphates previously used in laundry detergents[33]

Phosphates are all around us in the natural world. The metabolism of every organism, including humans, needs compounds that contain phosphate groups. If excessive amounts of phosphate enter lakes, however, as they did in the days when detergents contained phosphates, a surplus of plant nutrients can accumulate in the lake. This stimulates the growth of algae, which constitute most of the biomass in the water. The organisms that live on algae can therefore also multiply, and there is a knock-on effect at the next highest levels of the food chain. More algae means more photosynthetic activity, releasing oxygen, so that a surplus of oxygen accumulates in the upper layers of the lake. And because there is more biomass, more organisms die. The dead biomass sinks to the bottom of the lake, where microorganisms break it down aerobically, i.e. consuming oxygen as they do so. This results in a shortage of oxygen in the deeper water layers. In the absence of oxygen, anaerobic bacteria multiply, releasing toxic metabolic products as they do so. These toxic products cause many forms of life in the lake to die. The oxygen-depleted lake can no longer be used as a source of drinking water. Over-enrichment of aquatic systems with plant nutrients (C, N, P) is referred to as eutrophication.

Task

Add captions to the following diagram to illustrate the process of eutrophication. Use the following terms: *Phosphates, anaerobic digested sludge, strong plant growth, oxygen-rich, nutrient-rich, oxygen-depleted, nutrient-depleted*



The phosphate content of Lake Constance – Germany's biggest inland body of water – has been studied for many years. The knowledge gained can be applied to other bodies of water such as the North Sea and the Baltic. The diagram below shows the phosphate concentration in Lake Constance from 1950 to 2004.

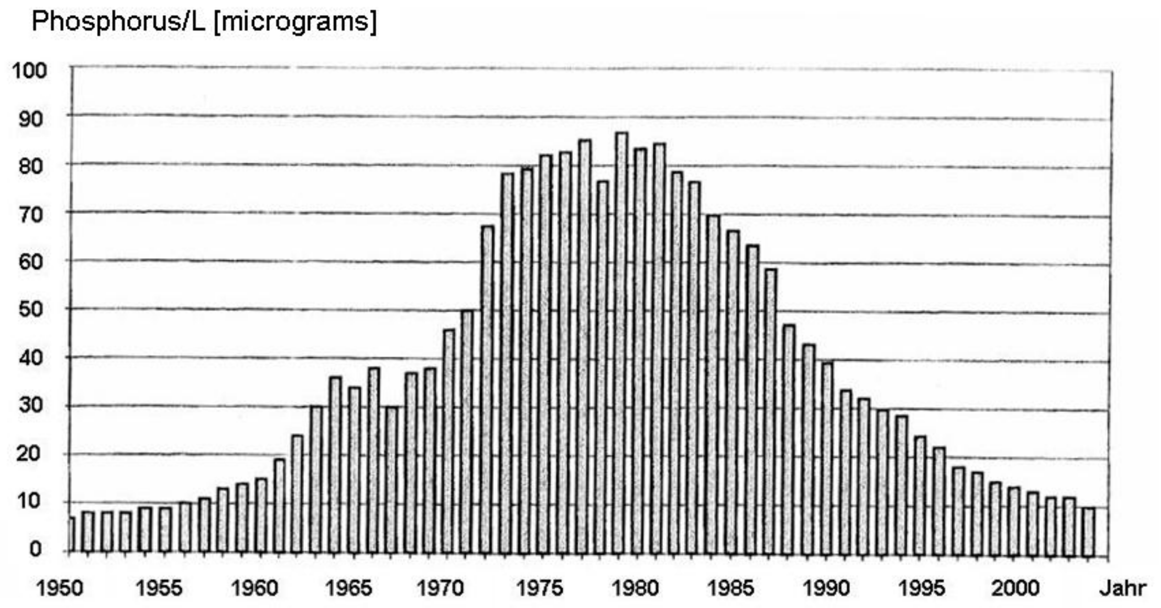


Fig. 1: Phosphate concentration in Lake Constance from 1950 to 2004

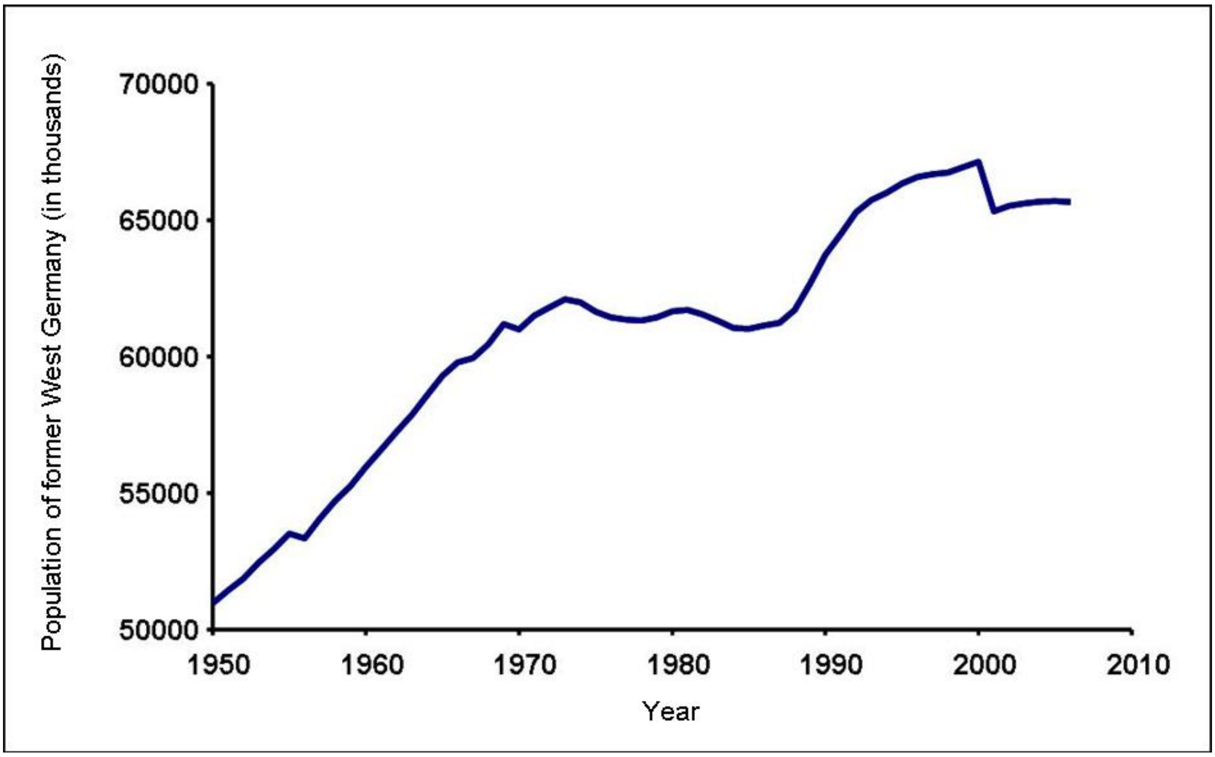
Task

Explain the curve of the phosphate concentration in Lake Constance. Draw on **Materials 6, 7 and 8** in your explanation.

[33] Worksheet and relating Materials 6-8 are taken from:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Material 6

Population of the former West Germany from 1950 to 2006:



Source: German Federal Statistical Office (*www.destatis.de*).

Material 7

The history of phosphate-free laundry detergents

Year	Event
From 1930	Phosphates present in laundry detergents
1950 – 1959	New raw materials such as the water softener sodium tripolyphosphate used in laundry detergents.
1966	Phosphates in laundry detergents are recognized as playing a key role in the eutrophication of lakes. The search for phosphate substitutes starts.
From 1970	Increasing emphasis on biochemical wastewater treatment
1973	Filing of patent application for phosphate substitute Zeolite A (brand name Sasil®).
1975	Environmental safety assessment of phosphate substitute Zeolite A in laundry detergents
1977	Successful trial of the first low-phosphate laundry detergent containing Zeolite A.
1983	The first completely phosphate-free laundry detergent is launched on the market. In the following years, phosphate-free laundry detergents become established in Western Europe.

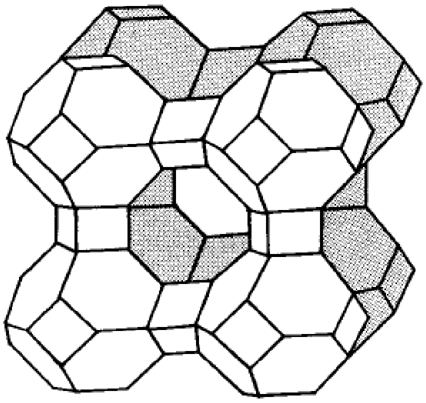
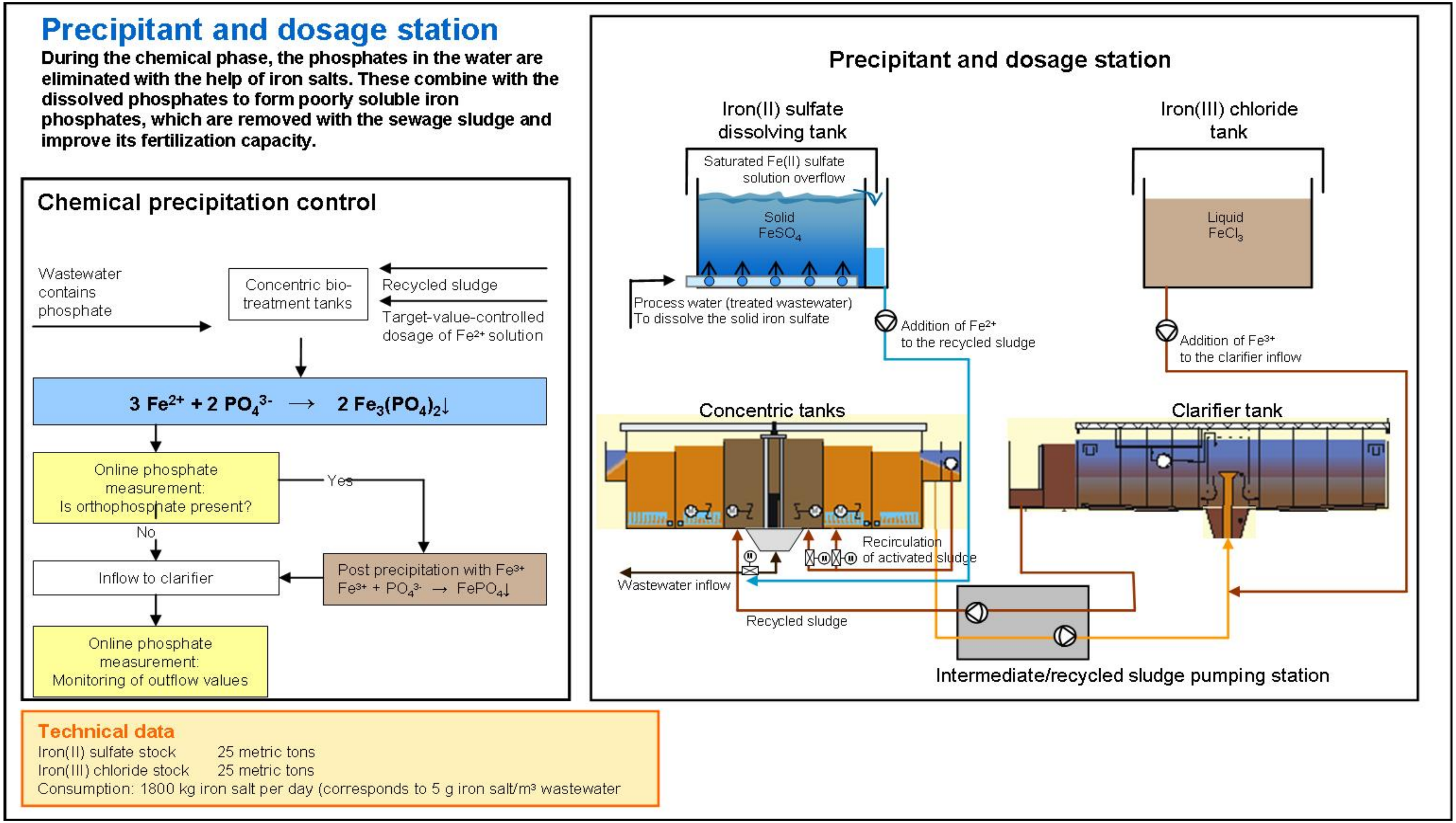


Figure: Sasil® crystal

Material 8

The central sewage treatment plant of the city of Constance is designed for a population equivalent of 215,000 and is the largest on Lake Constance. Each day, up to 40 million liters of wastewater are treated. This is equivalent to the content of about 2000 road tankers. The plant's precipitant and dispensing unit is shown in the diagram. (Source: Entsorgungsbetriebe Stadt Konstanz, *www.konstanz.de/imperia/md/content/ebk/89.pdf*)



Worksheet 21: Sustainability in the laundry detergent industry[34]

Climate change and the limited availability of water and energy are two major themes that affect us all. For this reason, many companies have undertaken to embrace the principles of sustainable development and social responsibility in the conduct of their business.

Many revolutionary advances of days gone by, such as the "self-acting detergent" and phosphate-free products are now established in our everyday lives. However, laundry detergent developers cannot afford to bask in the glow of yesterday's successes – today, ideas for improved and new products are in continuous demand. Responsible companies know that sustainability has three dimensions, all of which must be taken into account in their business practices:

Tasks

1) In Henkel's Sustainability Report 2007, you can find examples of innovations in the laundry detergent industry from the beginnings down to the present day. Read pages 3–7 of the Sustainability Report. You can find the report on the Internet at:
   http://www.henkel.com/cps/rde/xchg/henkel_com/hs.xsl/12152_COE_HTML.htm
2) Find examples of innovations and assign them to the above dimensions.
3) What are the advantages of these innovations?

[34] Worksheet taken from: http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Activity 3.9: Synthesis of bio-fibers

A) Synthesis of calcium alginate threads[35]

Apparatus and materials

- sodium alginate sol (ρ = 20 g/l)
- calcium chloride solution (c = 1 mol/l)
- deionised water
- beaker (250 ml)
- reaction tube (diameter: 2 cm, length: 25 cm)
- measuring cylinder (100 ml)
- rubber stopper to fit the reaction tube
- heatable magnetic stirrer and magnetic stirring bar
- glass rod
- syringe (2 ml) with injection needles (diameter: 0.45 mm, length: 12 mm)
- tweezers
- paper towels
- scale
- sieve

Procedure

- For preparing 100 ml of the sodium alginate sol, warm 80 ml of deionised water in the beaker to 70°C. Turn of the heat and increase stirring speed to a maximum so that a vortex forms. Sift 2 g of sodium alginale to the upper vortex wall and keep stirring until the sodium alginate dissolves (help out with a glass rod if needed, after turning off the stirrer).
- After the sol has cooled to room temperature, remove the stirring bar and clean it and the glass rod with deionised water over the beaker. Add deionised water to yield 100 ml and mix stir the sol again with the glass rod.
- Mount the reaction tube vertically, close the bottom with a rubber stopper and add 50 ml of calcium chloride solution.
- Fill the syringe (without needle) with 1 ml of the sodium alginate sol and clean the outside of the syringe with a paper towel. Let air bubbles in the sol rise to the tip of the syringe and then attach the needle.
- Pierce the rubber stopper of the reaction tube carefully and dress the sol into the calcium chloride solution carefully and evenly. After the syringe is empty, it is removed with the needle. Refill the syringe and repeat the above-described process of attaching a **NEW** needle.
- The thread will rise to the top and can be removed after 1 minute from the solution. Hang it up to dry and weigh the gained fibre.

Disposal

- Pour the calcium chloride solution and any remaining sodium alginate sol down the sink. Put the calcium alginate threads in the waste bin.

Further ideas

- Research what calcium alginate threads are used for.

[35] Source of experiment:
Marburger, A. (2002). Alginate in der Medizin: Anwendung in Wundauflagen, Dentalabdruckmassen und Medikamenten gegen Sodbrennen. *Praxis der Naturwissenschaften - Chemie in der Schule*, 51(5), 27-35.

B) Synthesis of polylactic acid fibres[36]

Apparatus and materials

- test tube
- test tube stand
- gas burner
- plastic weighing dishes (chilled)
- tin(II) chloride
- lactic acid
- beaker (small)
- anhydrous copper sulfate
- boiling chips
- pipette (5 ml)
- tweezers
- glass rod

Procedure

- Fill 3 ml of lactic acid, several crystals of tin(II) chloride and some boiling chips into a test tube.
- Heat for 10 minutes while constantly agitating it gently.
- During the heating, hold a small beaker over the test tube to collect the emitted steam. Test for water using the anhydrous copper sulfate.
- As soon as the content in the test tube turns orange to brownish, pour the hot and liquid contents onto a chilled plastic weighing dish.
- At the transition from liquid to solid, use the tweezers and glass rod to pull threads from the material.

Disposal

- Put the threads in the waste bin.

Further ideas

- Research what polylactic acid threads are used for.

[36] Source of experiment:
Huntemann, H., Parchmann, I. (2000). Biologisch abbaubare Kunststoffe: Einordnung in ein neues Konzept für den Chemieunterricht. *CHEMKON*, 7(1), 15-21.