WP3
Chemical Care

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

Work Package 3
UNIT CHEMICAL CARE
Teacher Information

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)

Version: 3.0

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Document History

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The worksheets, materials and experiments belonging to Activities 1.8, 3.6, & 3.8 were developed by:
Prof. Dr. Ilka Parchmann *(IPN Kiel),* Kerstin Haucke *(Carl-von-Ossietzky University of Oldenburg),* Prof. Dr. Alfred Flint, Alexander Witt, and Katja Anscheit *(University of Rostock) and* Dr. Romy Becker *(Henkel AG & Co. KGaA, Düsseldorf);* further worksheets and experiments are available in English at the following website:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Worksheets and materials in Subunit 3 were also developed in cooperation with Dr. Norbert Stelter *(Henkel AG & Co. KGaA, Düsseldorf).*

Other experiments and ideas were taken from the projects “Chemie fuers Leben” (German website with further links to experiments and material in German: http://www.didaktik.chemie.uni-rostock.de/en/forschung/chemie-fuers-leben/) and “Chemie im Kontext” (textbooks in German for lower and upper secondary level published by Cornelsen).

Sources are also listed on the worksheets.

A. Teacher Information

I. Unit description

“Forces and interaction between substances” is the central focus of this unit, including both concepts of chemical bonding and chemical reaction. The goal is to point out and develop the relevance of explaining properties and behaviour of substances as an interaction of the substance in a certain environment.
This principle is not only important for chemists but also for an understanding of phenomena and products in daily-life and industrial contexts. That is why a large number of activities in all of the three subunits deal with everyday substances, such as household cleaners or textiles/clothes. From this students can see that they are able to explain “trivial” processes such as drying their sport jacket on the radiator on a chemical basis.

The unit is divided into three subunits, based on the same developmental structure as the first ESTABLISH chemistry unit “Exploring Holes”:

Sub unit	**Student level**	**Title**
Subunit 1:	Early secondary level (10-12)	Become a Household Detective!
Subunit 2:	Mid secondary level (13-15)	Chemical Care at home
Subunit 3:	Upper secondary level (16-18)	Chemical Care for Functional Products

In Subunit 1, students will find out about household substances. They plan investigations to find out what happens if some of these substances are mixed and explain their findings on a phenomenological level.
In Subunit 2, students will focus more on the submicroscopic structure of household substances such as acids and bases, and learn to explain their functionality based on chemical explanations.
In Subunit 3, students look at textiles, their production processes and especially investigate the structure of and care for different types of fibres.

Linkage to the national curriculum:
For other national versions, please indicate links to the national curricula.

The chemistry curriculum in Germany follows the same structure as applied by the three sub-units: students first learn to observe and explain phenomena on a macroscopic level and to carry out simple experiments, mostly based on given instructions. Often in their second year of chemistry, particle models and the big idea of atoms are introduced and applied for different explanations. Further on, such models are specified and differentiated.
The National Standards for all German states structure the chemical content by four so-called basic concepts: (1) matter and particles, (2) structure-property-relations, (3) chemical reaction and (4) energy changes based on chemical processes. The three sub-units of this unit focus mainly on the concept of structure-property-relations.
The first sub-unit can be integrated in the curriculum of the first year in science or chemistry, often year 5 or 6 (age 10 - 12). In almost all German states, curricula demand the observation, description and identification of substances at this level, also their separation and first experimental analyses.
Sub-unit 2 can easily be connected to the curriculum topic of acids and bases which is usually treated on a submicroscopic level around year 9 (age 13/14). The students classify acids and bases using the definitions by Arrhenius or Brönstedt.

Sub-unit 3 builds on knowledge on organic substances and introduces or rather enlarges the knowledge about polymers. This will be dealt with in upper secondary level courses.

Discipline(s) involved: Chemistry, biology

Estimated duration:
Each sub-unit is flexible as they are designed to fit into a topic already taught in the curriculum and the material can be used in different ways and combinations.

II. IBSE Character

In all of the three subunits, the following aspects of IBSE are present, with different foci in the different subunits:

- Developing questions
- Developing hypotheses
- Testing hypotheses with experiments
- Documenting experiments
- Searching for information in books, the internet, and on products
- Discussing ideas with peers

Especially sub-unit 3 applies the IBSE steps both for scientific experiments and the idea of technical / industrial processes of the optimization of products.

III. Science Content Knowledge

Sub-Unit 1: Become a Household Detective!
For this sub-unit, only very basic knowledge about simple characteristics of the different substances used in the activities (salt, sugar, water, oil, washing powder, soap) is needed. This knowledge can be found in every science or chemistry textbook for introductory classes. In addition, basic knowledge about where to find bacteria is also needed.

Sub-Unit 2: Chemical Care at Home
As this unit focuses on products and processes related to curriculum units on acids and bases, this is also the knowledge background needed. Teachers must be able to choose household products, e.g. cleaners containing acids or bases. They must have general knowledge on the structures and properties of the substances, such as acidic acid, citric acid, or sodium hydroxide. Most important, they must consider all measures necessary for a safe realisation of students' experiments, as described in the material. However, as this content knowledge is also very basic and can again be found in any chemistry textbook, no further explanations are needed at this point.
Precautionary measures are important for the experiments with bacteria and nutrient agar to prepare it sterile and its disposal.
For further information about hygiene around the home, Dr. Norbert Stelter (Henkel *AG & Co. KGaA, Düsseldorf)* suggests the following website:
http://www.ifh-homehygiene.org/IntegratedCRD.nsf/IFH_Home?OpenForm

Basic knowledge about bacteria, fungi and viruses

Bacteria are microorganisms existing in large numbers. Bacteria live nearly everywhere, for example in the air, on objects, or in the water. People need bacteria as they help them but they may also cause diseases. A lipid membrane and a cell wall surround cytoplasm of the cell of the bacterium. The cell wall type affects major characteristics of bacteria. Bacteria are prokaryotes and do not have a nucleus. They also lack other components compared to other cell types. The cytoplasm carries the bacteria's genetic information in form of a circular chromosome which is to be found in the nucleoid. There are different cell morphologies and arrangements of bacteria, e.g. cocci or bacilli. Mostly, you can find a cell wall of peptidoglycan in bacteria which is essential for them to survive compared with fungi, which are eukaryotes and their cell walls are made up of chitin amongst others.

Sources:
http://de.wikipedia.org/wiki/Bakterien
http://en.wikipedia.org/wiki/Bacteria
Hans G. Schlegel (1992). Allgemeine Mikrobiologie. 7. überarb. Aufl.. Georg Thieme Verlag: Stuttgart. 22-26.

The function of proteins depends on its undisturbed molecular geometry. However, in the people's digestive tract proteins are only degradable after their denaturation. This can happen via cooking or gastric acid. This is an important process for the hygiene of food as it destroys not only bacteria but also fungi. By adding strong acids or bases, organic solvents such as alcohol, heat or concentrated inorganic salts (e.g. NaCl) to proteins they are destroyed as they lose their secondary (local segments in a three-dimensional form with regular repeating patterns) and tertiary structure (three-dimensional structure of greater segments) which are altered but the primary structure (peptide bonds between amino acids) stays intact. The result of denaturation of living cells is disrupted activity of cells (disrupted covalent and Van-der-Waals interactions between side-chains of amino acids), they cannot fulfil its function any longer, or the death of cells.
While heating intra-molecular bonds are released by vibrational excitation. By applying alcohol or inorganic salts to proteins not only their secondary and tertiary structure are destroyed but also their primary and quaternary (protein subunits spatially arranged) structure may be destroyed or disrupted due to the competition of building hydrogen bond. Also surfactants may alter proteins as they disrupt the non-polar bonds which are directed inside the protein. Additionally, surfactants may impair the structure of lipid membranes.

Sources:
http://www.chemieunterricht.de/dc2/wsu-bclm/kap_02a.htm
Wikipedia: http://de.wikipedia.org/wiki/Denaturierung_%28Biochemie%29
http://en.wikipedia.org/wiki/Denaturation_%28biochemistry%29

Fungi are microorganisms that belong to group of eukaryotic organisms. They have cell walls made up of chitin (glucose-derivative, polymer of a N-acetylglucosamine). Fungal cells have a cell nucleus which is bounded by two membranes, the nuclear membrane, and which carries the chromosomal DNA.

Sources:
http://en.wikipedia.org/wiki/Fungus
Hans G. Schlegel (1992). Allgemeine Mikrobiologie. 7. überarb. Aufl.. Georg Thieme Verlag: Stuttgart. 169-172.

Bacteria and fungi are able to spoil materials like food or microbial sensitive products because they may multiply and metabolise substances in such goods. Some bacteria and fungi are known to cause illness either as infectious organisms or due to metabolism products. Thus, it is necessary in selected cases to actively fight microorganisms to prevent illness or spoilage of goods. This covers also the preservation of potentially sensitive goods (e.g. cosmetics, water based cleaners, and detergents, or water based paints). Measures to prevent infectious diseases in the private area are summarised under household hygiene. The correct and targeted application of cleansers and detergents support household hygiene.

Viruses are particles on the borderline between inanimate nature and real organisms. Viruses are characterised by the fact that they do not have their own metabolism and thus, viruses do not spoil materials like food or microbial sensitive products. Viruses are not able to multiply themselves. They capture living cells to force them to produce viruses. This is the reason why viruses cannot be cultivated on ordinary nutrient media. Some of them are highly infective and some of the most severe infectious diseases are caused by viruses.

Source:
http://en.wikipedia.org/wiki/Virus

Sub-Unit 3: Chemical Care for functional products

This subunit focuses on different fibres, their structure, their production and their classification. Consequently, this unit applies more specific knowledge on different fibres such as cotton, silk, wool or nylon.
Materials that are discrete elongated pieces or continuous filaments can be classified as fibres. The manufacture of textiles as well as other industrial branches are using fibres. Fibres play an important role in the biology of plants and animals as they are structural elements stabilising tissues as building materials (spider nets, silk) or keeping the optimum body temperature (animals) as insulators (hairs).
Fibres can be subdivided in natural and synthetic fibres (see Figure 1 in classroom materials).

Fibres produced by animals, plants, or geological processes are called natural fibres. Natural organic fibres are biodegradable over a specific period of time. Classification is possible, based on the fibres' origin such as animal fibres (e.g. spider silk, wool or hair (e.g. angora, cashmere, or mohair)), vegetable fibres (often cellulose-based, e.g. cotton, flax, jute, ramie, or sisal), wood fibres, as well as mineral fibres (e.g. such of the asbestos group). Despite this variety in natural fibres and their availability, the production of synthetic fibres is often cheaper and yields can be obtained in larger amounts in comparison with natural fibres. Synthetic fibres can be specially designed to the area of application which enables the development of functional textiles and specific technical textiles.

Synthetic fibres can be subdivided in cellulose fibres (as such or by regeneration of natural cellulose), polymer fibres (synthetic chemicals-based fibres, e.g. polyamide, polyester, aromatic polyamides etc.), mineral fibres (such as carbon fibres, asbestos or fibreglass), and microfibers made of diverse materials.

Sources:
http://en.wikipedia.org/wiki/Fiber
Rösler, Friedrich. Naturfasern. NiU-Chemie 6 (1995) Nr. 26, Seite 5-8.
Karraß, Sigurd. Chemiefasern: Aufbau-Strukturen-Anwendungen. NiU-Chemie 6 (1995) Nr. 26, Seite 9-15.

Cotton, for example, is a natural fibre. Its fibres consist of about 91 % cellulose, 7.85 % water, 0.56 % protopectin, protoplasm and 0.20 % mineral salts. The spinning of cotton is enabled by a typical coiling of the mature fibre. The cellulose layers that are oriented in different directions to the vertical axis are the reason for the coiling.
Cotton is a fibre often used for textiles as it resists alkali treatment. It is, however, damaged by acids which weaken the fibre. Furthermore, it highly resists organic solvents while it is damaged by microorganisms such as mildew or rot-producing bacteria. Regarding the washing process, the fibre does not decompose before a prolonged exposure to temperatures of > 150˚C. However, exposed to flames, it burns readily.

Sources:
http://www.chemgapedia.de/vsengine/vlu/vsc/de/ch/16/mac/naturfasern/naturfasern.vlu/Page/vsc/de/ch/16/mac/naturfasern/baumwollfaser01.vscml.html
http://en.wikipedia.org/wiki/Cotton

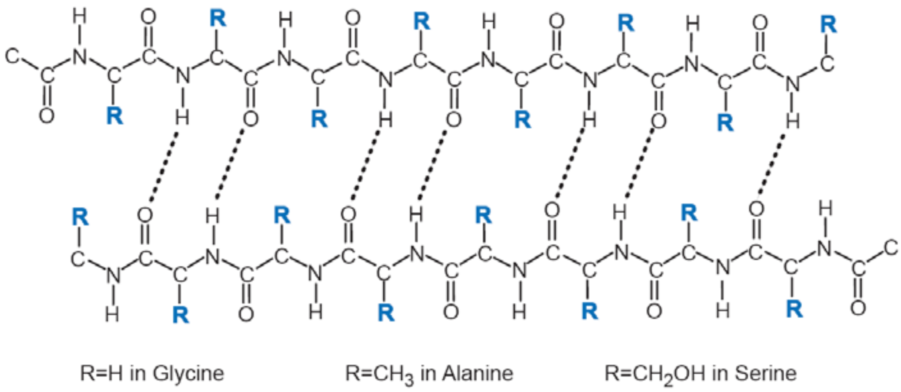
Another example of natural fibres is wool, which is produced as hair by animals. It can be obtained from different animals. Generally, the term wool is used for fibres from sheep but there are also cashmere and mohair from goats or angora from rabbits, among others.
As the fibre is a protein fibre and composed of more than 20 amino acids which form polymers, wool has special characteristics. The crimp formation, elasticity, staple and texture are influenced by the chemical structure of protein polymers. Furthermore, there can also be found calcium, fat, and sodium in the fibre. The fibrous structural protein of wool is keratin. The arrangement of parallel sheets of the outer layers of the polypeptide chains are connected via hydrogen bond. Tiny scales cover the central protein core of the fibre.
To list some important qualities of wool, it is hydrophilic, ready to absorb moisture, hollow, crimped and elastic. Wool grows in staples (clusters). Moreover, the ignition takes place at a higher temperature compared to cotton and it does not melt.

Source: Henkel. Waschen & Pflegen: Spezialratgeber Wolle. http://www.perwoll.de/waschen-pflegen/spezialratgeber/wolle-richtig-waschen.html#content61

Sources:
http://en.wikipedia.org/wiki/Wool
http://www.maxlawsoncarpets.com.au/why_wool.php?11/natural+fibres/163/wool
http://www.medicalsheepskins.com/wool.htm
Rösler, Friedrich. Naturfasern. NiU-Chemie 6 (1995) Nr. 26, Seite 5-8.

Silk is a natural fibre that is made up of proteins. The cocoons of the larvae of the mulberry silkworm are the base raw material of the silk fibre.

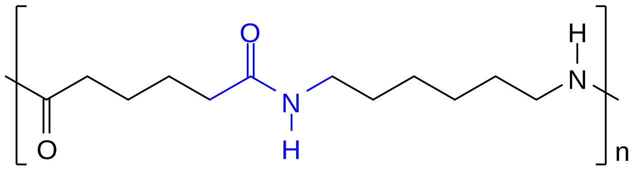
Excerpt from the secondary structure of a general silk protein, containing different amino acids:



Source:
http://en.wikipedia.org/wiki/Silk
Rösler, Friedrich. Naturfasern. NiU-Chemie 6 (1995) Nr. 26, Seite 5-8.

Nylon, first produced in 1935 by Wallace Carothers at DuPont's research facility in the USA, is a thermoplastic condensation polymer. It is a silky material which belongs to synthetic polymers due to its chemical structure. Nylon is polyamide 6.6 and is obtained of a diamine that is hexamethylene diamine (IUPAC name: hexane-1,6-diamine) and a diacid, namely adipic acid (IUPAC name: hexanedioic acid) in a condensation polymerization reaction. By that, repeating units are linked by amide bonds. Important characteristics due to the chemical structure are its high resistance to many chemicals, fungi, insects, mildew, molds, and rot. Besides, it melts instead of burning.

Excerpt from the Nylon structure:



Sources:
http://en.wikipedia.org/wiki/Nylon
Karraß, Sigurd. Chemiefasern: Aufbau-Strukturen-Anwendungen. NiU-Chemie 6 (1995) Nr. 26, Seite 9-15.

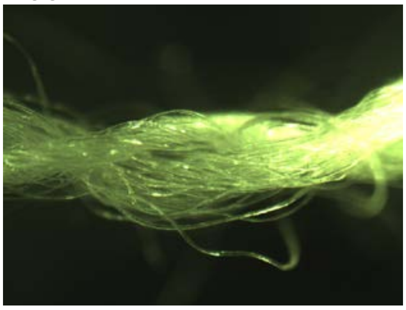
Additionally, **artificial/ viscose silk** is a half-synthetic fibre obtained from cellulose. **Microfibres** are fully synthetic fibres obtained from polyester or other fibres similar to Nylon.

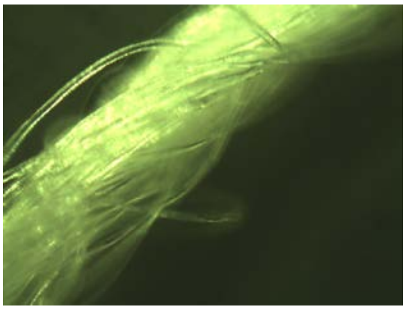
Thickness of fibres

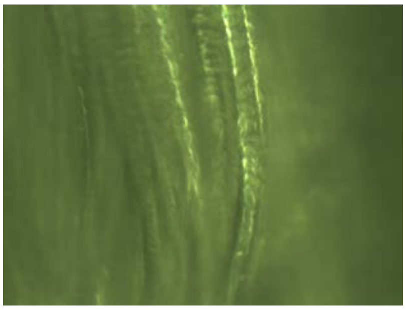
The following pictures of fibres were taken with a Motic BA 400 with different magnification (Source: Kirsten Fischmann, taken at IPN, Kiel, Germany):

4 x /0.10 | 10 x /0.25Ph | 40 x /0.65Ph

wool:

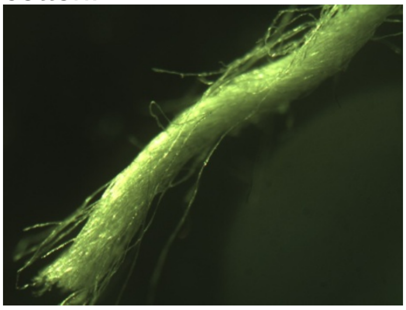


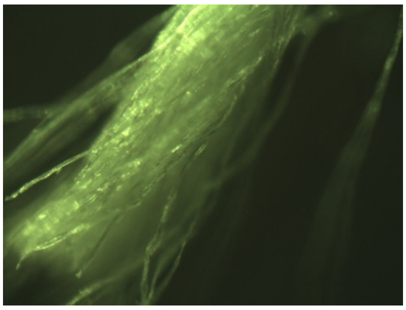




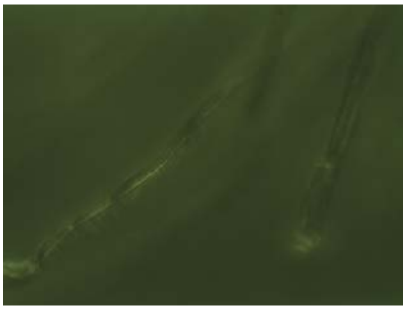
Here you can slightly see the scaly surface of the fibre.

cotton:

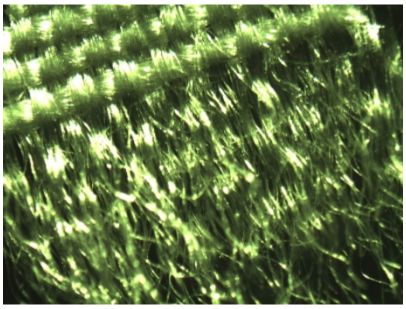


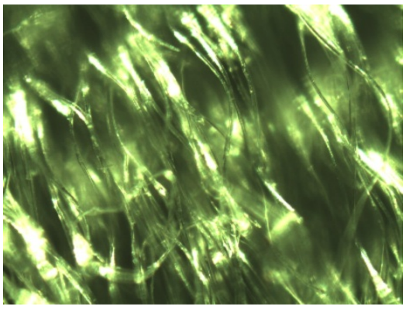


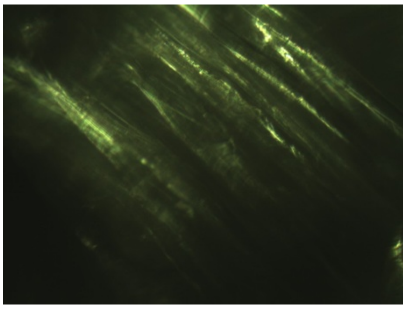
Notice the typical coiling of the fibre.



silk:

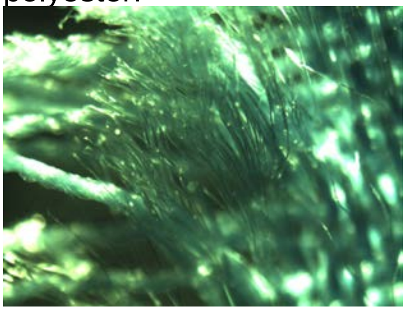


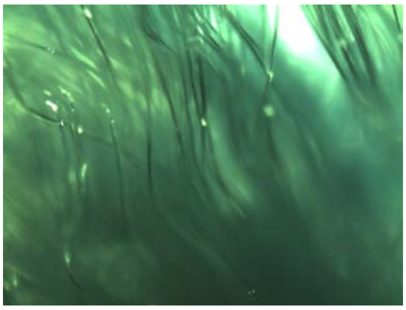


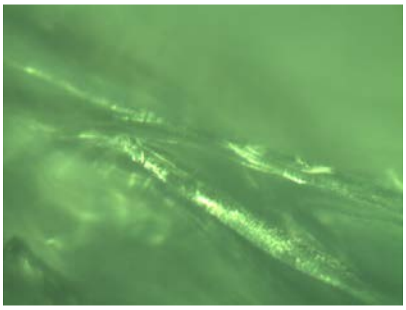


Slightly coiled fibre without scales.

polyester:



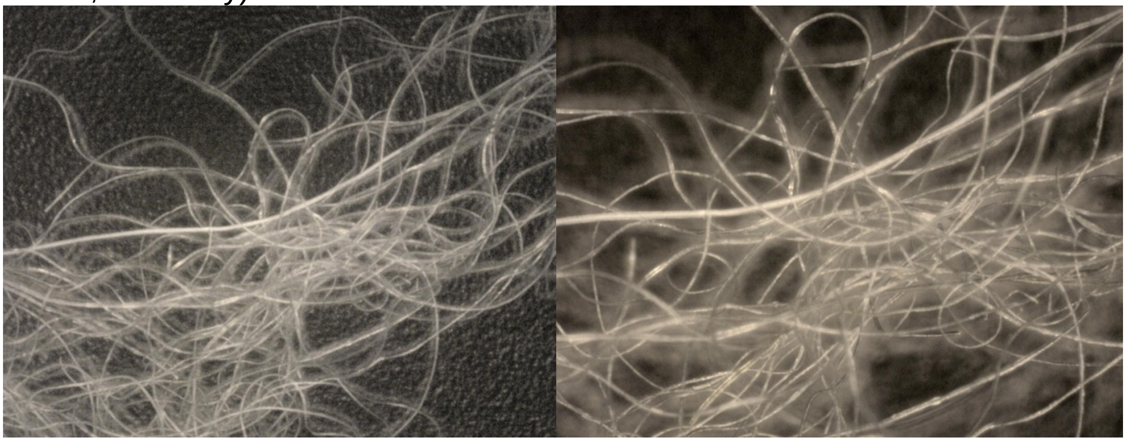




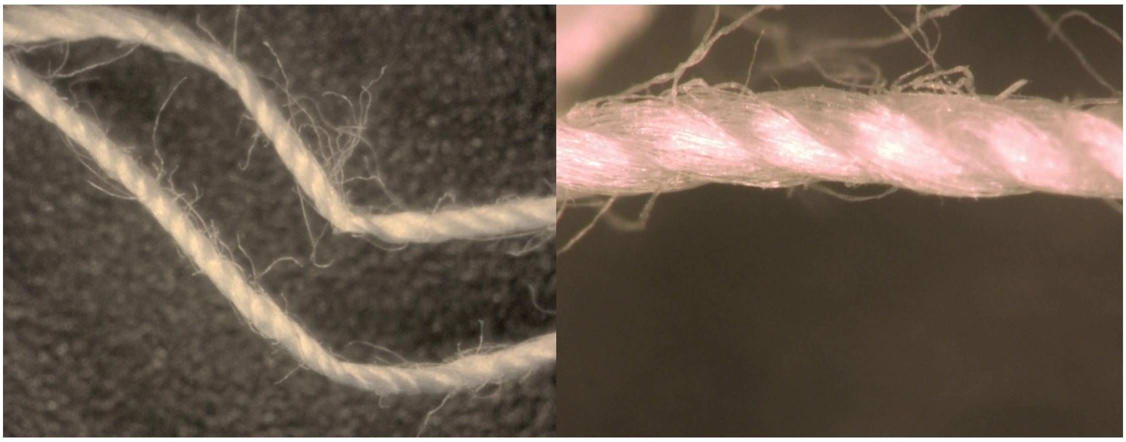
Straight fibre without scales.

The following pictures of fibres were taken with a Keyence Digital Microscope VHX-500F with up to 200x magnification (Source: Kirsten Fischmann, taken at Henkel AG & Co. KGaA, Düsseldorf, Germany):

lamb wool fibres

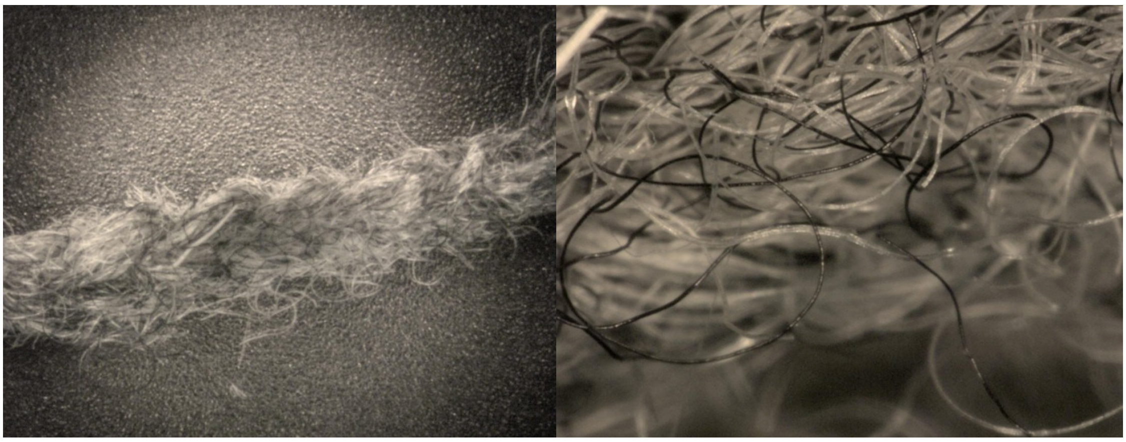


cotton fibres

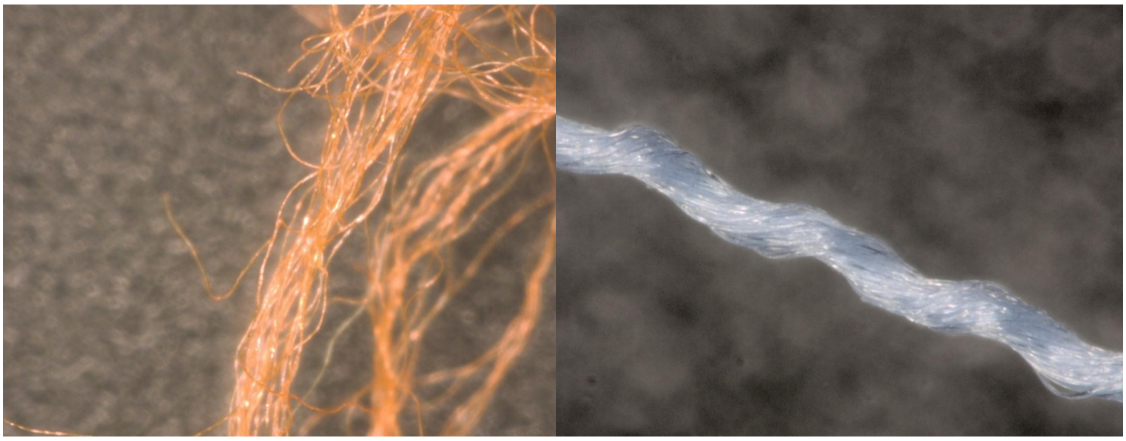


cotton, piece of textile

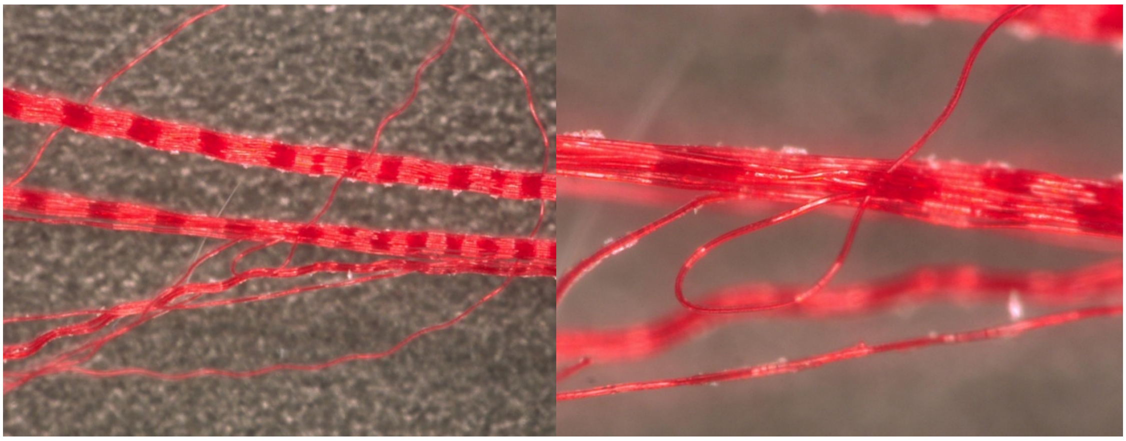
virgin wool fibre



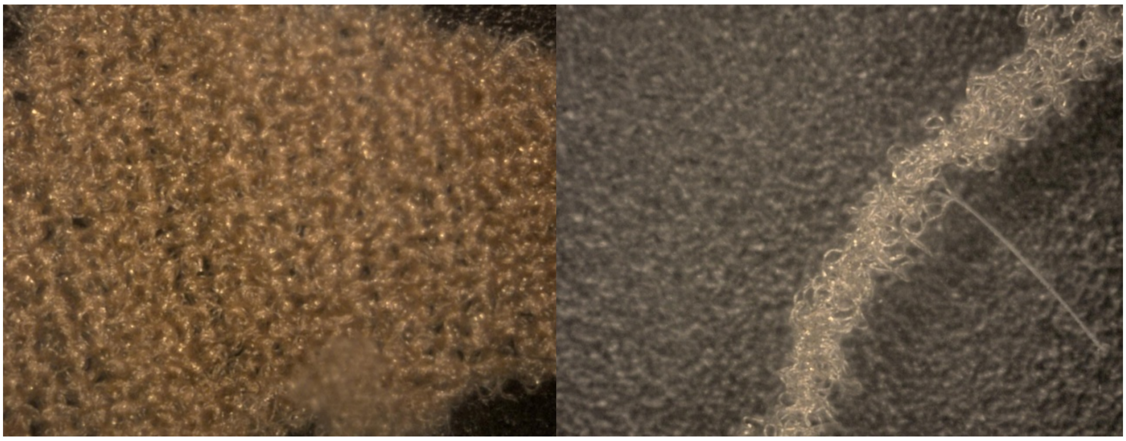
different polyester fibres



polyamide fibres



nylon tights



Methods for making semi-synthetic fibres

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)

Apart from the above mentioned natural and synthetic fibres, there are fabrics with a porous or closed surface. The fabric / surface is characterised by its specific micro-structure which is made up by nodes. The latter exhibit an interconnection between fibrils. These textiles offer special properties such as being waterproof and breathable what hints at their usage. Examples for these special membranes are Gore-Tex®, SympaTex®, or Nomex®.

Gore-Tex® is a membrane of polytetrafluoroethylene. The special characteristics of this fabric are its waterproofness and breathability.

Size of islands about 10µm.
Figure adapted from: http://en.wikipedia.org/wiki/Gore-Tex

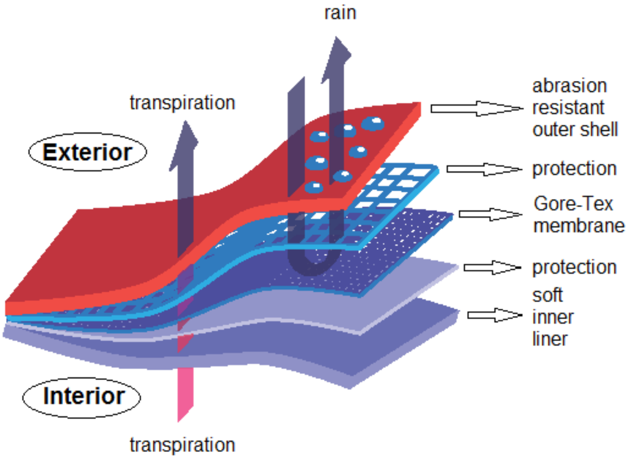
SympaTex® is a non-porous membrane which is a hydrophilic block copolymer made up of polyether-ester. The special characteristics of this fabric are as well its waterproofness and breathability but also its windproofness.

Source: http://en.wikipedia.org/wiki/SympaTex

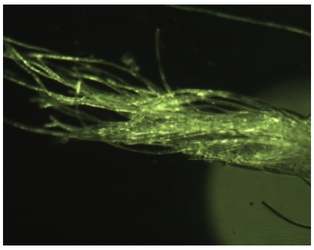
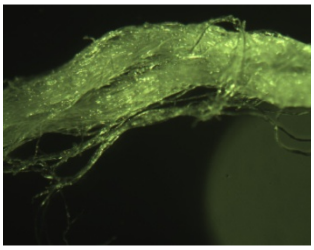
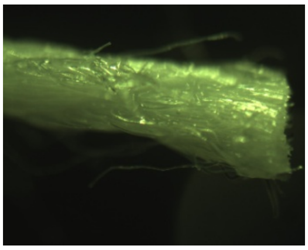
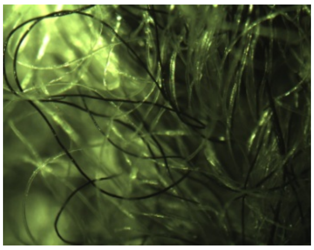
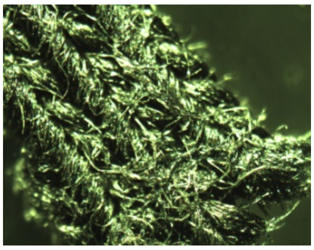
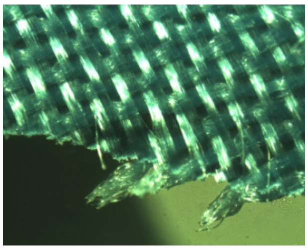
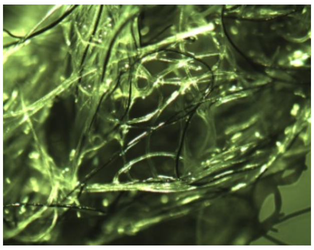
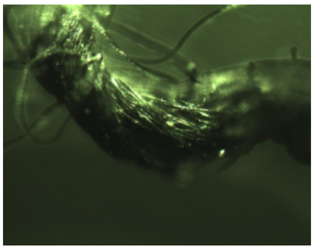
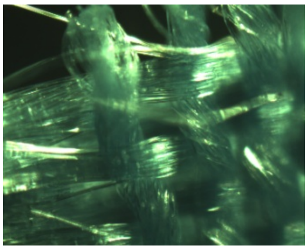
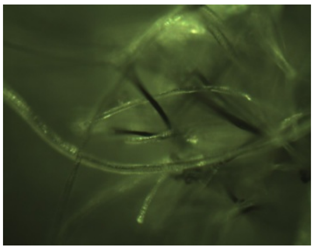
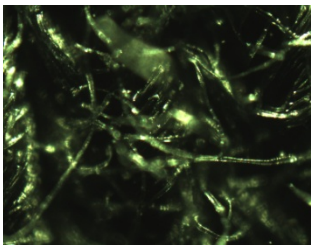
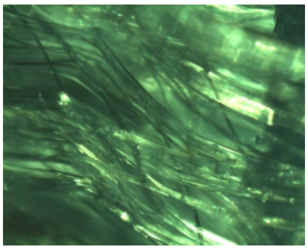
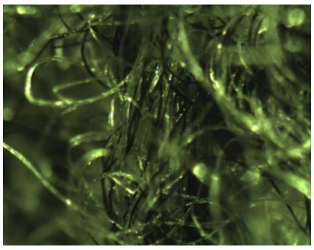
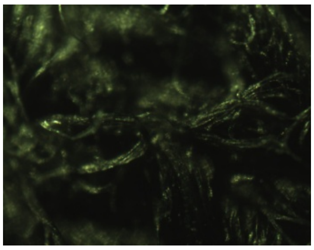
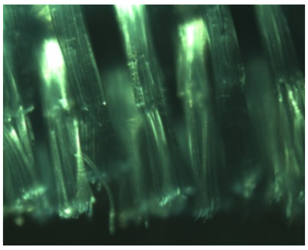
Nomex (styled NOMEX)® is an aromatic polymer of polyamide. Due to its stable molecular structure it is used as a flame resistant fabric.

Source: http://www.mueller-ahlhorn.com/de/Nomex.html

These membranes make up one part of functional clothes, often consisting of several layers. The following picture shows a structure of such a layered textile:



The following pictures were taken after treatment with different detergents.

type of fibre: laundry detergent:	wool	cotton	polyester
All-purpose detergent: Persil-Universal-Powder 5 g in 100 ml H_20, 90 min. at 40°C pH = 10,74			
Mild detergent: Perwoll – care for fine fabrics (liquid) 5 ml in 250 ml H_20, 110 min. at 40°C pH = 7,97			
soapsud: Fa Bar Soap Vitalizing Aqua 3 g in 250 ml H_20, 180 min. at 40°C pH = 9,33			
soapsud: washing soda 2 tablespoons in 250 ml H_20, 180 min. at 40°C pH = 11,26			
acidic solution: vinegar cleaner 5 ml in 250 ml H_20, 180 min. at 40°C pH = 3,75			

Background information on detergents

Solid or powdery all-purpose detergents can be used for washing processes at temperatures between 20°C and 95°C for all white and non-fading textiles of natural (e.g. cotton) and synthetic fibres with the exception of wool and silk but it depends on the textile itself which temperatures are appropriate. Bleaching agents in them are needed to remove bleachable spots as coffee or red wine. During the washing process the bleach system consisting of a peroxide compound and TEAD (Tetraacetylethylenediamine) deliberates peracetic acid which does not only bleach stains but is an effective antimicrobial substance. Thus, solid bleach containing all-purpose detergents are suitable for textiles with significant hygiene relevance (e.g. kitchen textiles) when used with a washing temperature of 40°C or higher. Liquid detergents normally do not contain bleaching agents however, they adhere better to spots. Furthermore, all-purpose detergents are basic. Due to their alkalinity and their content of protease enzymes, all-purpose detergents normally are not suitable for protein fibres like wool or silk.

As **wool and silk** belong to the fibrous structure proteins, a laundry detergent with a neutral pH value is needed. An alkaline pH of all-purpose detergents or detergents for bright colours causes the wool scales to open, they act as barbs, fibres are locked together and this leads to fulling and felting as well as contracting/ shrinking of the wool fibres which cannot be retrieved. Moreover, the detergent must not contain the enzyme protease as it would destroy the fibres as it conducts proteolysis. In this process peptide bonds linking amino acids are hydrolysed. Besides, wool has an effect of natural purification. The core of the wool fibre absorbs water / moisture while washing and soaks which makes the wet fibre sensitive. In the washing process the wool fibres move against one another. Due to that the rotational frequency of washing machines should be reduced as well as the temperature of the washing process (special washing programme for wool, cold – 40°C) and a special detergent for wool and silk (pH ≤ 8, special ingredients for a good foam formation) should be used to gain optimal care for wool. This also applies to silk which loses its resistance to tearing when washed with all-purpose detergents.
Mild detergents are used for the washing of fine coloured fabrics of natural and synthetic fibres (e.g. viscose) with the exception of wool and silk. They can be used at temperatures of 30°C to 60°C. They contain surfactants and are weak basic.
Detergents for bright colours can be used for washing processes at temperatures between 20°C and 60°C for all textiles of natural and synthetic fibres with the exception of wool and silk. They do neither contain bleaching agents nor optical brighteners but enzymes for spot removal. They are basic and gentle to colours.
Detergents for special fabrics e.g. detergent for wool and silk are suitable for textiles of wool and silk and fibre-mixtures of them. They are used at washing temperatures from cold to 40°C. Their pH value is neutral. They do not contain hurtful enzymes to preserve the fibres.
There are some more special laundry detergents as for example detergents for drapes, for journeys (travel detergents) and for sportswear and functional textiles.

Sources:
Richtig Waschen: Informationen rund ums Waschen – Spülen – Reinigen. Jens Gebhard, Christa Wolf, Kerstin Ochs. Henkel AG & Co. KGaA. Redaktion: Consumer Relations. Düsseldorf, 2008. pp. 11-14. 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

Water containing cleansers and detergents are in principle microbiological sensitive. A microbial attack or spoilage may occur due to bacteria in the environment breaking down biodegradable ingredients, such as e.g. enzymes or surfactants as they are organic. This can typically only be prevented by adding preservatives. Preservatives can function in different ways: they can influence bacterial DNA, their protein synthesis, their cell membrane or cell wall, among other things. Some formulations are resistant against a microbial attack due to their high surfactant concentration or their content of short chain alcohols or the extreme pH. During the product development process new formulas are checked for microbiological stability. In case a sufficient stability can be achieved only by addition of a preservative, the effectiveness and stability of the chosen preservative must be proven by suitable tests. Usually, preservatives approved for cosmetics are also used for laundry detergents and washing additives.

Sources:
Wagner, Günther (2005). Waschmittel: Chemie, Umwelt, Nachhaltigkeit. 3., vollst. überarb. u. erw. Aufl. Weinheim: Wiley-VCH Verlag. p. 116.
Lück, E. & Jager, M. (1995). Chemische Lebensmittelkonservierung: Stoffe, Wirkungen, Methoden. 3.überarb. Auflage. Berlin: Springer Verlag. p. 40-43.
Laundry Detergent Ingredients: Information Sheet. WashWise: A fresh approach to doing the daily laundry. Date of access: July 30, 2012.
< http://www.washwise.org.au/_documents/Laundry%20detergent%20ingredients%20info%20sheet.pdf>.

In the last years some innovations came up regarding the functionality of fabrics. There are different methods that are used to produce for example antimicrobial textiles. These textiles are used in medical areas, such as in infection prophylaxis in medical institutions to control the transmission of pathogenic germ or with people suffering from neurodermatitis as people fear of pathogenic organisms, germs and body-odour (caused by metabolites which are the result of the propagation of bacteria, the silver ions stop the propagation and the bad smell can be stopped as well) which make up the basis for 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 other 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 may contain small amounts of the metal, in the form of nanoparticles that release ions slowly over time. By these additives antimicrobial textiles should not give bacteria a chance to deposit on textiles. Silver ions have various effects upon bacteria. Silver ions attack the organism's hereditary information of the bacteria and block important enzymes in the microbe/ microorganism. Furthermore, they break through the bacterial capsule and/ or cell wall. Silver ions have an effect upon the bacteria which get into the textiles via sweat/perspiration. So the body-odour is prohibited as well as the settlement/ colonization with pathogenic germs. The precious metal silver is known for its good (skin) tolerance and causes allergies only rarely. Although the textiles could be bought for years, there are only a few studies regarding the effects and impacts on microbial particles. Up to now the question of the building up of resistance, i.e. bacteria learn at regular contact with virtually deadly substances (e.g. silver ions) to resist them, is unclear.

Sources:
Welt Online. Schweissgeruch. “Hightech-Textilien als Geheimwaffe gegen Stinkefüße”. Peggy Freede. 04.03.2011. http://www.welt.de/wissenschaft/article12698561/Hightech-Textilien-als-Geheimwaffe-gegen-Stinkefuesse.html
Bild der Wissenschaft. Materialforschung. „Grün für Silber“ 17.01.2011. http://wissenschaft.de/wissenschaft/news/312728.html
Henry Fountain “Anti-Odor Silver Exits Textiles in the Wash”. The New York Times. Published: November 2, 2009. http://www.nytimes.com/2009/11/03/science/ 03obsox.html

The following table shows a selection of available experiments on fibres, fibre synthesis and functional clothes, as can be found in German textbooks and journal articles.

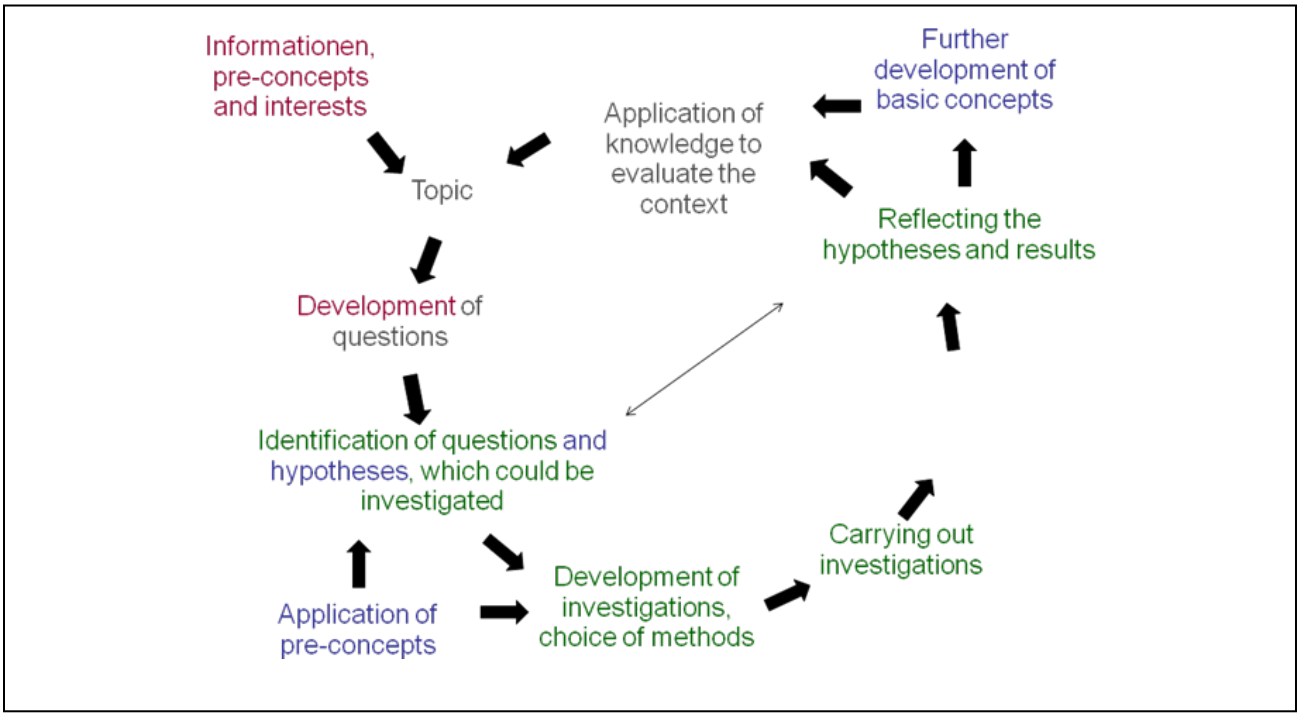
For adapting this table to the national standards, each partner should research national material.

	Source
1. Syntheses that can be performed in school: a) Nylon® b) Polycaprolactam (Perlon®) c) Artificial silk d) PLA (polylactide)	a) Chemie im Kontext (2006). Berlin, Cornelsen Verlag, Material 7.3 of the student disc c) (s. Chemie heute – AB) d) Remus, L. (2005). PLA aus Milchsäure. PdN-ChiS, 54(4), p. 44-47.
2. Differentiation of types of fibres a) Test for behaviour when felt b) Test for behaviour when wrinkled c) Test for behaviour when burned d) Test for behaviour when smoldered – dry destillation e) Test for behaviour when applying bases f) Test for behaviour when applying acids g) Test for behaviour when applying acetone h) Test for behaviour when applying a drop of water i) Identification of non-dyed fibres with neocarmine-dye	▪ Pfeiffer, B. & Schmidkunz, H. (1995). Unterscheidung von Faserarten und Bestimmung von Fasern – Einfache Verfahren. *Naturwissenschaften im Unterricht - Chemie*, 6 Nr. 26, 21-23. ▪ Schmidkunz, H. (1995). Die Identifizierung von Fasern mit Neocarmin-Farbstofflösungen. *Naturwissenschaften im Unterricht - Chemie*, 6 Nr. 26, 24-25. ▪ Sawal, H.-B. (1997). Identifizierung von Textilfasern durch Experimente. *Praxis der Naturwissenschaften – Chemie*. 5/46. 30-32.
3. Properties of textiles a) Permeability regarding air b) Permeability regarding water c) Permeability regarding steam d) Amount of water absorption e) Insolating properties f) Behaviour when heated	
4. Treatment of fibres a) Dying (material e.g. cotton, linen, silk, wool, cellulose acetate, polyacryl, polyamide, polyester) b) Washing c) Ironing d) Waterproofing e) “Smell“proofing	Lehmann, D. & Pfeifer, P. (1995): Färben von Naturfasern und synthetischen Fasern mit Naturfarbstoffen. *Naturwissenschaften im Unterricht - Chemie*, 6 Nr. 26, 26-29.

IV. Pedagogical Content Knowledge

The unit on chemical care wants to enhance the students' thinking of substances in interaction with their environment. This is a more complex view than just describing substances and their properties. Research on structure-property-relations (summarised e.g. by Scheffel et al., 2009) points out that students often focus only on one criterion instead of the interaction of different criteria influencing a property or a behaviour. Even in complex structures, properties are sometimes referred to as properties of individual atoms. Additionally, macroscopic properties are sometimes transferred onto sub-microscopic structures in a misleading way, such as giving colours to atoms. The approach of this unit is to avoid this narrow thinking right from the beginning by pointing out the use, the behaviour and the consequences of substances in an environment, not isolated from it. The level of complexity develops from sub-unit to sub-unit, but each new sub-unit should be connected to the knowledge already developed before.

Regarding the method or pedagogical teaching and learning approach, all sub-units allow the students to develop their own ideas for experiments and explanations, of course guided by the material. Next to the guideline of IBSE, context-based learning (see a connection of approaches in Bulte, Pilot & Gilbert, 2006, or in Nentwig & Waddington, 2005) is applied in the design of the units and the material. In sub-unit 1, the students are led through the activities by the story ("storytelling") of becoming a household detective. Sub-unit 2 also situates the activities in the students' home, this time focussing on cleaners and the help of chemical knowledge for a careful treatment of their own and their families' health as well as of objects at home. Sub-unit 3 deals with clothes and fibres, both embedded in daily-life situations, and in industrial contexts.
All sub-units can be structured along the following phases (see Nentwig et al., 2007):



References:
Gilbert, J., Bulte, A. & Pilot, A. (2006). Special Issue on Context-based learning. *International Journal of Science Education (IJSE)* 28/9
Nentwig, P., Demuth, R., Parchmann, I., Gräsel, C., Ralle, B. (2009). Chemie im Kontext: Situating Learning in Relevant Contexts while Systematically Developing Basic Chemical Concepts. Journal of Chemical Education, 84(9), 1439-1444.

Nentwig, P., Waddington, D. (Eds.)(2005). *Making it relevant. Context based learning of science*. Münster: Waxmann.

Scheffel, L., Brockmeier, W., Parchmann, I. (2009). *Historical Material in Macro-Micro Thinking: Conceptual Change in chemistry Education and the History of Chemistry*. IN: Gilbert, J., Treagust, D. (Eds.). Multiple Representations in Chemical Education. Dordrecht: Springer.

V. Industrial Content Knowledge

Sub-unit 1 is not related to industrial processes directly, but it can be connected to especially community plants e.g. by the following activities:

- Students can search for products and how they are described and produced on the internet, connecting the products they have found in their house to producers and selling companies / stores.
- Teachers can decide to connect the "household detective" activities about analyzing substances to a visit in a water plant / wastewater treatment station to compare different ways of chemical analyses.

Sub-units 2 and 3 are already based on co-operations with industry, here with the example of the Henkel Company. Students should not only learn about the chemistry of e.g. cleaners or fibres, they should also learn about how and why they are produced and optimized in certain ways. Industry can provide information on different levels, for example through

- websites or booklets about the historical development of a certain product;
- a real or virtual visit to a plant producing a certain product;
- real or podcasted interviews with experts working in the production or the management, giving information on how and why decisions are taken and a new process is initiated and more.

Background information on the company

Henkel AG & Co. KGaA, a multinational personal care company, was founded in 1876 in Aachen as Henkel & Cie by Fritz Henkel and two other partners. Today the company is headquartered in Düsseldorf, North Rhine-Westphalia, in Germany.

Henkel has three worldwide operating business areas which are Laundry & Home Care, Cosmetics/Toiletries and Adhesive Technologies. The company employs about 48,000 employees worldwide. Globally it holds leading market positions both in the consumer and industrial businesses. Its most famous brand is Persil, the first commercial laundry detergent. Other well-known brands are Schwarzkopf and Loctite, for example.

Henkel products range from household cleaning products (laundry detergents or dishwashing liquid (Persil, Spee, Vernel/Silan, Somat etc.)) over personal care products (shampoo, toothpaste, hair colorants etc. (Schauma, Fa, Diadermine etc.)) to adhesives, sealants and surface treatment products for consumer and industrial purposes.

In regard to possible links to industry as described in D3.0 "Guide for developing ESTABLISH teaching and learning units", most activities deal with analyzing or working with an industrial product (either directly such as finding out about household cleaners or analyzing different pieces of textiles, or indirectly such as consequences of acids on organic materials). Following are exemplary activities showing a connection to specific types of ICK:

- students are analyzing household cleaners (subunit 1) as products from industry → ICK type 3
- students can discuss whether home-made cleaners (soaps) are “better” than industrial products (→ products made by chemical industry are often considered “bad” in the media; they will find out that home-made soaps cannot be “free of chemicals”, as is a popular advertising slogan) → ICK type 1 (link to industry, discussing social perception of products/science)
- possible visit to a community water treatment plant or production facility for cleaning agents → ICK type 2
- students will learn about how and why cleaners/fibers are produced and optimized in certain ways (subunits 2 & 3) → ICK type 5
- activities on acids → ICK type 1 (link to industry through using products for experiments)
- activities on designing the ideal fibre/cleaning agent → ICK type 4 (incorporating chemical knowledge and social/historical issues, dealt with in prior activities)

VI. Learning Path(s)

In all three sub-units, students are introduced into some basic chemical knowledge about structure-property relations, they are enabled to enhance that knowledge based on further investigations, and they are invited to become creative about thinking of new products or ways of presenting ideas to others.

Sub-unit 1 offers basic knowledge on approaches to describe, to structure and to systemize “chemical substances” that students can find at home.
In a second phase, they carry out experiments to deepen their knowledge on properties and behavior of such substances in different environments, e.g. by mixing them or changing conditions such as the temperature. They should develop a deeper knowledge e.g. on systematic tests of solubility (salt / oil / coffee in water), heatability (salt, sugar water), effects on organism (bacteria, skin) etc.
From this, they can draw conclusions about safe treatments which they are invited to present in the third phase.

Sub-unit 2 wants to engage the students in using and enlarging their chemical (and biological) knowledge for the explanation of processes related to cleaning demands in the household. As this might not always be an encouraging topic for 13-14-year-olds, the sub-unit describes several stimulating and sometimes maybe surprising experiments that the students can carry out themselves.
The basic background they should build up throughout the sub-unit is led by the question of how to classify dirt they can see and “dirt” they cannot easily find, such as bacteria. They shall be able to differentiate between hydrophilic and hydrophobic dirt (polarity of structures), living dirt (protein membranes of bacteria), fibre dirt (basic structures and functional groups / reactivity); different cleaning agents such as water / acids / bases / alkanes / acetone (classification).
They should enlarge their knowledge by carrying out experiments to investigate interaction between dirt and cleaning detergents, and they should interpret their findings based on what they had learned about solubility and reactions with focus. On the sub-microscopic level, they should use models about inter- or intramolecular bonding and reactions.
In the third phase, the students are invited to create “the optimal cleaning agent”, designing a product and a strategy to sell it and explain its properties according to its chemical functionality for different situations and environments.

Sub-unit 3 lays or enhances a content knowledge background on fibres used in clothes. The students will analyse structures and properties and will learn how to classify polymers. They investigate different fibres in different products, e.g. the effects of weather (water, temperature), skin (moisture, temperature, skin) and washing detergents (different ingredients, temperature).
The investigations and the discussion of results shall lead to a deeper understanding of structure-property-relations in changing environments, applying model-based explanations and systematic series of experiments along the IBSE structure.
In the closing phase of the sub-unit, the students are invited again to become creative: They should invent “the dream fibre” or “the dream detergent” with argumentations based on structure-property-knowledge, IBSE structure for engineers, and STS arguments.

Student Learning Activities

Activity	***Inquiry type***	***E-emphasis***
1.1 Formulating questions	open inquiry	engagement
1.2 Formulating hypotheses	open inquiry	exploration
1.3 Planning an investigation	bounded inquiry	exploration
1.4 Carrying out experiments	bounded inquiry	exploration / explanation
1.5 Transfer of knowledge	--	explanation / evaluate
1.6 Further applications I	open inquiry	exploration
1.7 & 1.8 Further applications II	bounded inquiry	exploration
1.9 Further applications III	bounded inquiry	explanations
2.1 Which household products contain acids?	guided discovery	engagement / exploration
2.2 How much acid do we find in a household product?	guided discovery	exploration
2.3 Why do companies include acids into cleaning products? – Intended effects	guided discovery	explanation
2.4 Which effects can acids have on different materials and on our health? – Not intended effects	guided discovery	explanation / extend
2.5 Comparison of the effectiveness of different household detergents	guided discovery	explanation / evaluation
3.1 Analyzing fibres	guided discovery	exploration
3.2 The history of fibres	--	engagement
3.3 Production processes of textile fibres	--	engagement
3.4 Characteristics/Properties of fibres	guided inquiry	exploration / explanation
3.5 Membranes – Multifunctional fabrics	guided inquiry	exploration / explanation / extend
3.6 Keeping textiles clean	guided discovery / inquiry	exploration / explanation
3.7 Economic view on textiles	--	evaluation
3.8 Ecological view on textile care	--	evaluation
3.9 Synthesis of bio-fibres	--	extend / evaluation
3.10 The dream fibre/plant	--	extend / evaluation

VII. Assessment

For assessment, both IBSE-steps and content knowledge on structure-property-relations should be taken into consideration.
The students' understanding of important IBSE steps in scientific and in industrial engineering processes can be assessed during the units in a formative way. The usual approach is of course to assess the protocols the students often have to write following an experimental investigation. Making use of modern techniques, an alternative and probably more stimulating method would be a student's documentation by taking photos or producing a little film about an experiment. The latter can include the macroscopic level as well as the sub-microscopic level.

A comparison of an IBSE process carried out to investigate the properties of a detergent (= a scientific approach) and the optimization of a detergent (= an engineering approach) can help to find out how much the students have actually understood about the nature of science. Empirical studies show, for example, that students seem to have difficulties with the formulation and functionality of hypotheses in processes or seem to regard all experiments as approaches to optimise something, not to derive knowledge.

To test content-knowledge, tests should combine basic tasks with context related tasks to assess the students' abilities on application and transfer as well.

Again, formative assessment should be integrated as well.

VIII. Student learning activities

SUB-UNIT 1:

Overall learning aims:

Students learn a simple definition of chemical substances (and chemical reactions, depending on the curriculum). They learn how to characterize substances using different systematic approaches such as observation or experiments. They familiarize themselves with the steps of IBSE using experiments and learn how to document an experiment (protocol schemes).

The students take on the role as “household detectives”, investigating where they can find chemicals in their homes, what chemicals do to certain stains etc.
In order to benefit from this learning process, the following activities should be gone through chronologically by all students. Therefore, the activities are only described in a few words here and can be found in detail in the classroom material.

To start, divide the class into groups of “detective teams”. The following box names activities that can be carried out by those teams. While 1.1. to 1.3 are essential for all, the others can be chosen, arranged or divided by the teachers in different ways. The material describes a storyline that can be given or told to the students to structure their work.

Activity 1.1: Formulating questions

Learning aim:
Here the focus lies on having the students state what they would like to find answers to because it is crucial to involve students’ ideas and (mental) conceptions to make this unit interesting for them. Students learn to think about their environment carefully as it is crucial to raise their awareness about chemistry and dangerous substances.

Material:
see classroom material

Suggestions for use:
The students can think about their questions in their detective team.

Activity 1.2: Formulating hypotheses

Learning aim:
Here the focus lies on having the students state what they expect to find out. In their detective team they learn to formulate hypotheses regarding their research questions of Activity 1.1.

Material:
see classroom material

Suggestions for use:
The students can present their hypotheses to the other teams.

Activity 1.3: Planning an investigation

Learning aim:
Here the focus lies on having the students state how they want to proceed. The aim is to make them think about a structured and logical plan how to conduct experiments. Furthermore, students learn how to define chemical terms.

Material:
Instructions for this activity, paper and pencil, chemistry book, internet
see classroom material

Suggestions for use:
In their detective teams students can research, for example,

- what "chemicals" are;
- safety measures necessary for performing experiments (obligatory!);
- what symbols there are to classify chemicals regarding their hazard (obligatory!);
- what parents/friends think about using chemicals (doing interviews);
- how chemicals can be classified according to their properties (colour, state of matter, ...) etc.

Activity 1.4: Carrying out experiments

Learning aim:
While having a look at the laboratory equipment students learn about the various functions of the different tools. The students learn to plan experiments on their own. The students learn how to responsibly carry out experiments as well as to document them.

Material:
Laboratory equipment
see classroom material
Experiments with white substances

Suggestions for use:
The variety of experiments can be chosen by the teachers. Students should pay special attention to the

- safety regulations;
- control of variables and
- the documentation of their experiments (procedure and observation).

Activity 1.5: Transfer of knowledge

Learning aim:
Here students can deduce from chemical behaviour to household use. They learn to transfer their newly gained knowledge and apply it to daily life.

Material:
see classroom material

Suggestions for use:
The students can solve this activity in team-work.

Activity 1.6: Further applications I

Learning aim:
Here students hypothesize which chemicals they could use to reduce risks in the household.

Material:
see classroom material

Activity 1.7 & 1.8: Further applications II

Learning aim:
Here students investigate which chemicals can be used to remove different stains.

Material:
see classroom material

Experiments (for more guided versions regarding the experiments consider the instructions below)
Worksheet 1: Introduction and safety information
Worksheet 2: How are stains and dirt removed from clothes?
Worksheet 3: The influence of temperature on wash performance
Worksheet 4: Laundry detergents then and now
Worksheet 5: Laundry detergents and the environment
Experiment 1: Finding bacteria

Suggestions for use:
In their detective teams students can cover, for example,

- the differentiation between pure substance and mixture and/or
- what a chemical reaction is (basic level definition).

Activity 1.8 can be complemented with an industrial visit to a sewage treatment plant.

More Guided experimental instructions:

Regarding Worksheet 2:

Apparatus and materials:

- Hotplate
- 2 beakers (500 ml)
- Pieces of cloth
- Glass rod
- Thermometer
- Pipette (1 ml)
- Water
- Pieces of cloth
- Oil (e.g. bicycle oil)
- Liquid laundry detergent

Procedure:

- Take three pieces of cloth and carefully apply a little bicycle oil to each piece, so that a circular stain is formed. Leave the cloth for about 10 minutes, to allow the oil to dry.
- Add about 250 ml water to each of the two beakers.
- Place one of the beakers on a hotplate. Set the temperature control to 30°C and wait while the water heats up. Check the temperature at intervals with the thermometer.
- When the water in the beaker on the hotplate reaches 30°C, drop a piece of cloth into each beaker. Stir the contents of each beaker with the glass rod at intervals over a period of about 10 minutes.
- When the ten minutes have elapsed, use tweezers to take the pieces of cloth out of the water. Examine the cloth pieces to assess the wash result.
- Add 1 ml of the liquid detergent to the beaker containing water at 30°C to create a washing solution. Drop the third piece of cloth into the beaker. Leave it for 10 minutes, stirring occasionally with the glass rod. Remove the piece of cloth after 10 minutes and assess the wash result.

Observation and evaluation:

Piece of cloth washed with …	Wash result
water (cold)	
water (hot)	
wash solution (hot)	

Disposal

- Put the pieces of cloth in the waste bin.
- Empty the beakers (containing water, and detergent) down the sink.
- Put the residual oil into chemical waste.

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

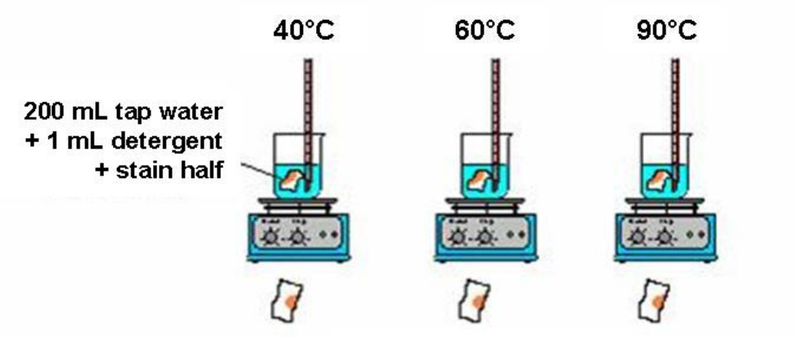
Regarding Worksheet 3:

Apparatus and materials:

- 3 beakers (250 ml)
- graduated cylinder (200 ml)
- 3 hotplates (with stirrer and 3 follower bars or glass rods)
- 3 thermometers
- 3 watch glasses
- Stopwatch
- Tweezers
- Scissors
- graduated pipette (1 ml)
- Pipette filler
- Liquid detergent for colored laundry
- 3 cocoa stains on cotton cloth

Procedure

- Cut out generous pieces of cloth, each with a stain in the center, and cut each stain in two. One stain half will be washed and the other will be used for comparison. Mark the stain halves with a pencil to identify them.
- Add 200 ml tap water to each beaker. Place each beaker on a hotplate and heat one to 40°C, one to 60°C and one to 90°C. Keep the temperatures constant. Cover each beaker with a watch glass.
- After the required temperatures have been reached, pipette 1 ml of the liquid detergent into each beaker. After the detergent has dissolved, drop one stain half into each beaker and start the stopwatch to count down 40 minutes. Stir the liquid in each beaker at intervals or, if stirrers are available, use the stirrers on a medium setting.
- When the 40 minutes have elapsed, take the stain halves out of the wash liquid and dry them. Compare them to each other and to their respective unwashed halves.



Experimental setup

Disposal

- Allow the wash liquid to cool and pour it down the sink.
- Reuse the cloths if possible, or put them in the waste bin

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

Activity 1.9: Further applications III

It depends on the facilities and regulations in each country whether the experiments with bacteria can be carried out.

Learning aim:
Here students investigate where potentially harmful bacteria can be found in the household and how they can be made visible. They transfer their gained knowledge to their household and reflect this topic.

Material:
Experiments: see classroom material

Suggestions for use:

- Students are to select places they want to test for presence of bacteria. Good places to check are light switches, water faucets, pullover sleeves before they go in the wash, ...
- Students should observe that bacteria colonies and fungi are obvious to varying extends after incubation, but that most detergents do not eliminate all bacterial growth.
- Suggest to the students using different concentrations of cleaners.
- Check with biology colleagues for disposal of bacteria cultures or do the following:
  – put in autoclave for min. 20 minutes at 121 °C or in pressure cooker for min. 30 minutes at 116 °C, inactivated material can be given into the dustbin or
  – contact hospitals or hygienic institutes to find out whether they will cover the disposal or
  – burn outside and not in vicinity of people/schools...

SUB-UNIT 2:

Overall learning aims:

The students should learn how to apply and enlarge their chemical knowledge to explain “normal” procedures and products in use at home. The topic of cleaners has been chosen even though it might not be the most interesting one to 13/14-year-olds as it offers a variety of stimulating experiments the students can carry out themselves.

The sub-unit can begin with newspaper articles on accidents in the household and / or advertisements for household products such as detergents and cleaners. The students can be invited to develop and collect explanations in small groups choosing different stories or advertisements. To do so, they have to apply their knowledge on substances and reactions. They are also asked to write down questions for aspects they cannot explain.

Following this broader collection, the students can decide together with the teacher which specific topics they wish to investigate further. One area would be the investigation of different cleaners, regarding general properties (e.g. solubility, pH), and effects on different stains. The result should be a table of substances, properties and suggestions for use, combining results collected from different groups. The process of investigation should follow the IBSE steps, as exemplarily described in sub-unit 1.

Activity 2.1: Which household products contain acids

Learning aim:
Here the focus lies on having the students state what they would like to find answers to.

Material:
Experiment: see classroom material

Suggestions for use:

- Many household substances can be analysed with an indicator in this way. Students can analyse various cleaners based on lemon or vinegar, lemon concentrate, essence of vinegar and decalcifying substances in either solid form (sometimes they consist of pure citric acid) or in liquid form (look for products containing a 50 % citric acid solution).
- The substances colour the dyed filter in different shades of pink. Based on the differences, students can deduce that there are different substances with acidic properties. From the differences in intensities, they can also see that there are variations regarding the intensity of acidic behaviour.
- Providing an opportunity for incorporating ICT: students could use a pH-meter when dealing with household acids (quantify how acidic solutions are; and for further activities how acidic it has to be to affect inorganic & organic substances, for example)

Activity 2.2: How much acid do we find in a household product?

Learning aim:
Here the focus lies on having the students state what they expect to find out.

Material:
Experiment: see classroom material

Suggestions for use:

- Students must be able to calculate volume-concentration-relations.
- Providing an opportunity for incorporating ICT: students could do titration with pH-meter to obtain digital neutralization curve (and use plotting software to digitalize results)

Activity 2.3: Why do companies include acids into cleaning products? – Intended effects

Learning aim:
Students learn to explain the functionality of acids based on their chemical structure and reactions.

Material:
Experiment: see classroom material

Suggestions for use:

- Since students know that lime scale build-up occurs in water heaters, this experiment can be used as an introduction to the process of calcification.

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

Learning aim:
Students learn to explain the functionality of acids based on their chemical structure and reactions.

Material:
Experiment: see classroom material, choose some or all experiments from Activity 2.4.1 to 2.4.4

Suggestions for use:

- The experiments show how acids react with different substances, such as bone, meat, marble or metals.
- For Activity 2.4.5:
    - In the first research Activity, students will check out companies (by a real or virtual visit or descriptions found online) and their treatment of acidic waste. Here, they might already find out about both *neutralization* and *dilution* as two options to decrease the concentration of acid in a solution.
    - In the second part, students will themselves perform a neutralization and/or dilution. In both cases, the step-by-step change in acid concentration can be both measured and tracked by using pH-meters, for example, and/or calculated to visualize the change in acid concentration. In this activity, it would be nice to use acidic household cleaners, as they are the starting points of the students' inquiry; a transfer to other acids used in the laboratory is also possible, however.

Activity 2.5: Comparison of the effectiveness of different household detergents

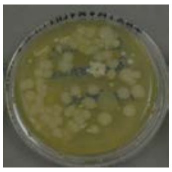
It depends on the facilities and regulations in each country whether the experiments with bacteria can be carried out.

Learning aim:
Students learn something about the effectiveness of household detergents because there are differences in their function, as e.g. only some are antibacterial.

Material:
Experimental: see classroom material

Suggestions for use:

- This activity provides an opportunity to combine biological topics with chemistry, e.g. in terms of enzymes and detergents.
- Have students repeat procedure using chemicals at different concentrations (alkaline, neutral, acidic) instead of cleaners.
- Contact plates should be sealed before incubation with Parafilm® tape or something similar to avoid contamination and exposition.
- The plates should be sealed after incubation.
- After working with bacteria, work areas and hands should be disinfected.
- Check with biology colleagues for disposal of bacteria cultures or do the following:
  - put in autoclave for min. 20 minutes at 121 °C or in pressure cooker for min. 30 minutes at 116 °C or
  - contact hospitals or hygienic institutes to find out whether they will cover the disposal or
  - burn outside and not in vicinity of people/schools...

Possible result after incubation: 

Activity 2.6: The optimal cleaning reagent

Learning aim:
Students learn to use the structure-property-knowledge obtained so far. Along the lines of STS approaches, they use logical reasoning skills to argue hypothetically which characteristics should be combined to generate the perfect cleaning reagent.

Material:
Results of Activities 2.1 - 2.5

Suggestions for use:

- Students can assess desirable and problematic properties of cleaners presented so far

SUB-UNIT 3:

Overall learning aims:

In this unit, students shall get to know different types of fibres, both synthetic and natural ones. They are also familiarized with the fibres' synthesis, both in laboratory and in industry. While describing the fibres' use based on their properties, students will learn to differentiate between the macroscopic and the sub-microscopic levels.

III.I Fibres in clothes: analyses of structures and properties

- Basic knowledge: classification of polymers
- Classification and structure (incl. pictures) of fibres (synthetic vs. natural fibres)
- Industrial production of fibres

Activity 3.1: Analyzing fibres

Learning aim:
The pictures present the structure and the composition of fibres. Students work with authentic materials to get to know both natural and synthetic fibres (compare figure 1: classification/synthesis of textile fibres). For several types of fibres, their synthesis is analyzed in regard to polymer mechanisms.

Material:
- Various pictures of different types of fibres, taken with high resolution camera and microscope.
- Experiments: Syntheses of various types of fibres.

Suggestions for use:
- The images of differently scaled fibres are compared. The fibres are looked at more closely at their submicroscopic level. The fibres' properties can be worked out through the existence of functional groups. From the pictures, the composition of the fibres, their size and their chemical structure can be analyzed.
- Students can also collect types of fibres from their own clothes and analyze those.
- Providing an opportunity for incorporating ICT: students can make own pictures with digital microscopes

Activity 3.2: The history of fibres

Learning aim:
This activity is to introduce students to the historical developments of different fibres.

Material:
Books or other resources, internet

Suggestions for use:
- Research activity in which students can gather information on the developments of different fibres
- Can be done in group work
- Students can present their findings to each other
- Activity can be done with or without going into chemical details, depending on focus, time and knowledge of students

- Providing an opportunity for incorporating ICT: students can be shown historical movies or video clips on how fibres/fabrics were made historically; or research aspects for example about the historical development of a certain product can be included (industry websites)

Activity 3.3: Production processes of textile fibres

Learning aim:
Students familiarize themselves with the production process of textiles by following the path of the raw material such as cotton through the different production steps.

Material:
internet, informational material, videos or other teaching material
Worksheet 6: The spinning process

Suggestions for use:

- This activity can be complemented with an industrial visit to a fibre production plant.
- This activity can be worked on in groups
- Other processing methods (spinning and weaving methods) can also be covered.
- Providing an opportunity for incorporating ICT: teacher can use animations/simulations (video?) on the process of making fibres or do a virtual visit to a plant producing a certain product
- Providing an opportunity for incorporating ICT: include aspect where students can create/watch podcasted interviews with experts working in the production or the management, giving information on how and why decisions are taken and a new process is initiated etc.

III.II Fibres in products: interaction with weather (water, temperature), skin (moisture, temperature, skin) and washing detergents (different ingredients, temperature)

- Deeper analyses: structure-property-relations in changing environments, model-based explanations and systematic series of experiments
- Characteristics of fibres e.g. behaviour of the fibre in acid/base, water and various washing detergents, in the washing process or while ironing (information on care labels)

Activity 3.4: Properties of different fibres

Learning aim:
Through various experiments, students learn about the properties of different fibres. Here, students are to find out what makes textiles comfortable to wear in certain situations or how certain textiles are to be treated.

Material:
Experiments investigating properties of textiles made of different fibres (e.g. wool, silk, cotton, rayon...; have students collect different clothes samples):

- 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

For ideas on experiments, see descriptions below.

Suggestions for use:

- The experiments described in the Classroom Material section can be used as a starting point; encourage students to improve them, however, to make the procedures more standardized and comparable.
- Students should be guided to think about how their findings relate to the everyday use and care of textiles made of different fibres.
- This activity can also be carried out in groups, in which the groups can be divided according to a) each group performing the same experiments but with different textile samples or b) each group performing different experiments with the same material sample.
- Providing an opportunity for incorporating ICT: use (digital) temperature sensor for heating properties; (show video clip on properties of functional fabrics used for specific situations, e.g. from discovery channel: clip on marathon runner with normal clothes and with special running clothes in weather)

Activity 3.4: Characteristics/ Qualities of fibres

These are only suggestions. Students will be much more motivated if they can think up their own ways to test these properties, as can be seen by the adaptations made on the photographs (taken by Joachim Borchert):

1) Permeability regarding air

Material:
Plastic syringe (100 ml), stop watch, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
air

Procedure:
Fill the plastic syringe with 80 ml of air. Keeping the textile sample pulled firmly over the opening of the syringe, push the air through the textile sample by applying steady force on the plunger. Pay attention to applying the same force with all textile samples. Record the time it takes to push all 80 ml through the textile sample. Sort the textile samples according to their permeability regarding air.

possible questions:
- What is the reason for the difference in permeability regarding air?

2) Permeability regarding water
a) Water drops

Material:
Plastic pipette, small beaker or small (marmalade) jar, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
Tap water

Procedure:
Stretch the textile sample over the jar and put a drop of water on the sample.

possible questions:

- What can you observe regarding the water drop on the different textiles?
- How can you explain your observations?

b) Jet of water

Materials:
Plastic syringe (100 ml), stop watch, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
Tap water

Procedure:
Fill the plastic syringe with 80 ml of water. Keeping the textile sample pulled firmly over the opening of the syringe, push the water through the textile sample by applying steady force on the plunger. Pay attention to applying the same force with all textile samples. Record the time it takes to push all 80 ml through the textile sample. Sort the textile samples according to their permeability regarding water.

Possible questions:

- What is the reason for the difference in permeability regarding water?

3) Permeability to steam

Materials:
Electric water boiler, test tube, spatula, gas burner, paper towel, marmalade jar with perforated lid or beaker, stop watch, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
Copper sulfate pentahydrate, tap water

Procedure:
Heat the blue copper sulfate pentahydrate in a test tube over the gas burner. Pour boiling water in the marmalade jar, stretch the textile sample over the jar and close the lid. Place a paper towel over the lid and some white copper sulfate on the paper towel. Record the time until the copper sulfate indicates a water presence.

Disposal:
Copper sulfate pentahydrate can be collected and reused.

Possible questions:

- What is the reason for the different permeability regarding steam?

4) Amount of water absorption

Materials:
Scale, 5 beakers (100 ml), ring stand and ring, watch, a pair of tongues, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
Tap water

Procedure:
Determine the weights of the dry textile samples. Insert each textile sample for 2 minutes into 50 ml of tab water. Let the textile samples hang for 5 minutes to remove the excess water. Weigh the textile samples again.

Possible questions:
- How much water does each textile sample absorb?
- How can you explain your observations?

5) Insulating properties

Materials:
Erlenmeyer flask (100 ml), stop watch, gas burner, rubber band, thermo element, ring stand and ring, cork ring, textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Chemicals:
Tap water

Procedure:
Heat 40 ml water in an Erlenmeyer flask to 65°C. Wrap the textile sample around the Erlenmeyer flask and fix in place with the rubber band. The flask can be placed on the cork ring. Determine the time it takes for the water to cool from 60°C to 50°C.

Possible questions:
- How can you explain the differences in insulating properties?

6) Behaviour when heated

Materials:
Hot plate, aluminium foil, marker, **small pieces** of textile samples (e.g. cotton, polyamide, wool, silk, polyester, PVC)

Note:
Experiment is to be performed under the exhaust hood!

Procedure:
Place a layer of aluminium foil over the hot plate. Place a textile sample on the aluminium foil and mark its size. Heat the hot plate first to 50°C, then to 100°C, then to 150°C and finally to 200°C, waiting for 1 minute between the heating increments and observing the textile sample. Note how the textile samples change and at which temperature.

Possible questions:
- How can you explain the differences in heating behaviour?

Activity 3.5: Membranes – Multifunctional fabrics

Learning aim:
Students learn that the processing of textiles leads to different membranes which have different properties. Furthermore, membranes can undergo other treatments in order to show specific properties.

Material:
Research pictures of different layers of a membrane used in functional clothes such as Gore-Tex® or similar.
Membrane samples to perform same experiments as in 3.4 (textile samples can either be worn clothes or producers can be asked for defect clothes items that had been returned to them)

Suggestions for use:
- Compare layers of functional clothes with those of TetraPak, have students draw analogies with the functions of the layers and discuss why/why not those layers could also be used in textiles.

Activity 3.5.1: Innovation in the clothing industry

Learning aim:
Students learn that the processing of textiles leads to different membranes which have different properties. Furthermore, membranes can undergo other treatments in order to show specific properties.

Material:
Worksheet 7

Tasks:
1. Find out about the underlying principle. Explain it. You may paint a model to explain the steps. (Search the internet for material and information)
2. List 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.

Suggestions for use:
- Students should work in teams to compare the statements and work on the two tasks with the given worksheet.
- Students can use their knowledge they gained in biology lessons.
- Finally, students should present their ideas and evaluation.

Activity 3.6: Keeping textiles clean

Learning aim:
Students learn that washing detergents, composed of certain chemicals, interact on a molecular level with certain fibres (and therefore also with textiles made of these fibres). In order to do this, students also analyze detergents in regard to their chemical composition.

Material:
- information material, such as textile care symbols and instructions
- experiments investigating what happens when care instructions are not followed

Experiments:
Worksheet 8: Research project
Worksheet 9: How bleaching agents work
Worksheet 10: The development of laundry detergents – from laboratory to production scale
Worksheet 11: Behaviour of fibres during washing process

Suggestions for use:
- This activity (esp. Worksheet 10) can be complemented with an industrial visit (e.g. Henkel AG & Co. KGaA). There further questions can be researched, such as how the components of laundry powder are evenly mixed or how the powder is kept dry during storage.
- For motivation purposes, in the series of experiments investigating what happens when care instructions are not followed, the students can develop their own ideas how to set up experiments testing those properties taking into account comparability and generalizability of their experiments.
- The experiment in D: Students may bring different detergents from home as well as fibre samples from old clothes they do not need any longer if there are no samples at school. Instead of using beakers, students can use yoghurt cups but they cannot be heated!
- Students may work in teams of two: every team gets every type of sample fibre and tests their interaction with one detergent. They should prepare two differently concentrated solutions of their detergent.
- Finally, students present their observations. They might use a camera to keep records of their findings.
- This activity lends itself to going beyond the visible observations and taking into account the chemical structures of different fibres and the interactions between chemical structure and laundry detergent.

III.III Fibres in society: economic viewpoints and sustainability

Activity 3.7: Economic view on textiles

Learning aims:
Students come into contact with economic perspectives of the textile industry.

Materials:
Information material, internet

Suggestions for use:

- This activity can be compiled together with colleagues from the social sciences department.
- Focus can be laid either on the ratio of current producers (producing countries) of different textiles or on working conditions in different countries, etc.
- Providing an opportunity for incorporating ICT: include aspect where students can create/watch podcasted interviews with experts working in the production or the management, giving information on how and why decisions are taken and a new process is initiated etc.

Activity 3.8: Ecological view on textile care

Learning aims:
Students learn about ecological consequences of detergents used to clean textiles.

Variety of experiments (for detailed experimental descriptions, see below):
Worksheet 12: The influence of temperature on wash performance
Worksheet 13: Improving wash performance by adding stain remover
Worksheet 14: The effect of laundry detergent dosage and water hardness on wash performance
Worksheet 15: The influence of laundry detergents on the growth of cress plants
Worksheet 16: Biodegradability of surfactants – Part 1
Worksheet 17: Biodegradability of surfactants – Part 2
Worksheet 18: Biodegradability of surfactants – Part 3
Worksheet 19: Biodegradability of surfactants – Part 4
Worksheet 20: Ecological impacts of the phosphates previously used in laundry detergents
Worksheet 21: Sustainability in the laundry detergent industry

Suggestions for use:

- This activity includes several experiments that focus on the sustainability of laundry detergents. The experiments can be performed in the form of a learning cycle or different experiments can be selected to be performed by the whole class.
- Providing an opportunity for incorporating ICT: include aspect where students can create/watch podcasted interviews with experts working in the production or the management, giving information on how and why decisions are taken and a new process is initiated etc.

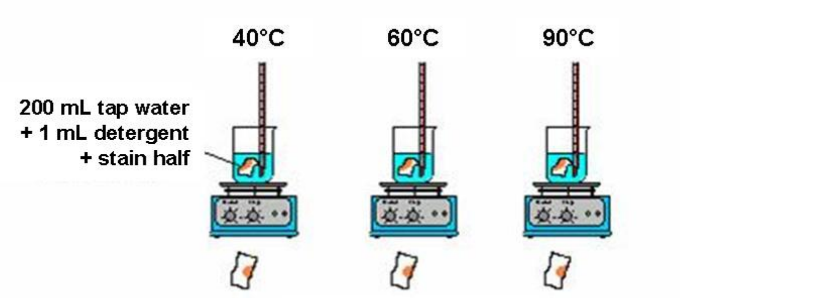
Regarding Worksheet 12:

Apparatus and materials

- 3 beakers (250 ml)
- graduated cylinder (200 ml)
- 3 hotplates (with stirrer and 3 follower bars or glass rods)
- 3 thermometers
- 3 watch glasses
- stopwatch
- tweezers
- scissors
- graduated pipette (1 ml)
- pipette filler
- liquid detergent for colored fabrics
- 3 cocoa stains on cotton cloth

Procedure

- Cut out generous pieces of cloth, each with a stain in the center, and cut each stain in two. One stain half will be washed and the other will be used for comparison. Mark the stain halves with a pencil to identify them.
- Add 200 ml tap water to each beaker. Stand each beaker on a hotplate and heat one to 40°C, one to 60°C and one to 90°C. Keep the temperatures constant. Cover each beaker with a watch glass.
- After the required temperatures have been reached, pipette 1 ml of the liquid detergent into each beaker. After the detergent has dissolved, drop one stain half into each beaker and start the stopwatch to count down 40 minutes. Stir the liquid in each beaker at intervals or, if stirrers are available, use the stirrers on a medium setting.
- When the 40 minutes have elapsed, take the stain halves out of the wash liquid and dry them. Compare them to each other and to their respective unwashed halves.



Experimental setup

Disposal

- Allow the wash liquid to cool and pour it down the sink.
- Reuse the cloths if possible, or put them in the waste bin

Source of experiment:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

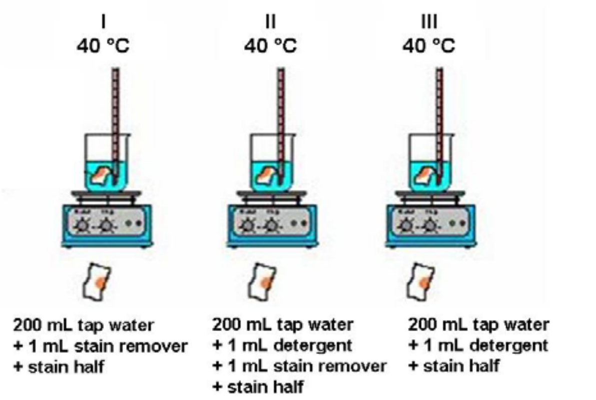
Regarding Worksheet 13:

Apparatus and materials

- *same as in experiment in Worksheet 12 plus*
- graduated cylinder (10 ml)
- stain remover

Procedure

- Cut out generous pieces of cloth, each with a stain in the center, and cut each stain in two. One stain half will be washed and the other will be used for comparison. Mark the stain halves with a pencil to identify them.
- Add 200 ml tap water to each beaker. Heat all three to 40°C and keep this temperature constant. Cover each beaker with a watch glass.
- Use the graduated cylinder to add 1 ml stain remover to beaker I and beaker II, then pipette 1 ml liquid detergent into beaker II and beaker III.
- After the detergent has dissolved, drop one stain half into each beaker and start the stopwatch. Leave beakers I and III for 40 minutes, and leave beaker II until the stain has almost disappeared (this can take between 10 and 20 minutes). Stir the liquid in each beaker at intervals or, if stirrers are available, use the stirrers on a medium setting.
- When the 40 minutes have elapsed, take the stain halves out of the wash liquid and dry them. Compare them to each other and to their respective unwashed halves.



Experimental setup

Disposal

- Allow the wash liquid to cool and pour it down the sink.
- Reuse the cloths if possible, or put them in the waste bin.

Source of experiment:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

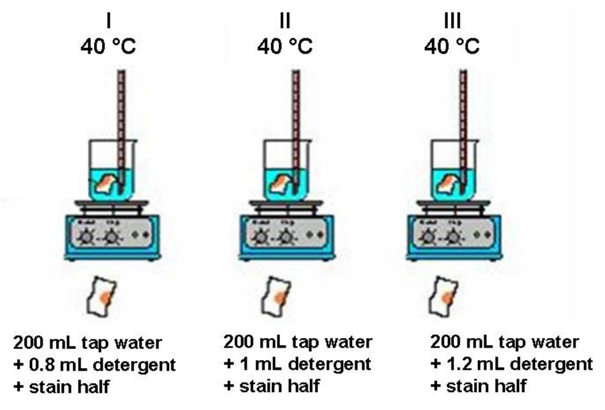
Regarding Worksheet 14:

Apparatus and materials

- same as in Worksheet 12 but:
- graduated pipette (**2 ml**)

Procedure

- Cut out generous pieces of cloth, each with a stain in the center, and cut each stain in two. One stain half will be washed and the other will be used for comparison. Mark the stain halves with a pencil to identify them.
- Add 200 ml tap water to each beaker. Heat all three to 40°C and keep this temperature constant. Cover each beaker with a watch glass.
- Pipette 0.8 ml liquid detergent into beaker I, 1 ml into beaker II, and 1.2 ml into beaker III.
- After the detergent has dissolved, drop one stain half into each beaker and start the stopwatch to count down 40 minutes.
- Stir the liquid in each beaker at intervals or, if stirrers are available, use the stirrers on a medium setting.
- When the 40 minutes have elapsed, take the stain halves out of the wash liquid and dry them. Compare them to each other and to their respective unwashed halves.



Experimental setup

Disposal

- Allow the wash liquid to cool and pour it down the sink.
- Reuse the cloths if possible, or put them in the waste bin.

Source of experiment:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

Regarding Worksheet 15:

Apparatus and materials

- 7 dishes (e.g. crystallizing dishes)
- 1 knife
- beaker (50 ml)
- graduated cylinder (100 ml)
- 2 beakers (500 ml)
- stirring rod
- graduated pipette (20 ml)
- pipette filler
- felt-tip pen
- liquid detergent for colored fabrics
- 4 trays of garden cress

Procedure

- Take the cress out of each tray, together with the mat in which it is growing. Use the knife to cut each mat in two. Place each half in its own dish. One half is left over.
- Place the seven dishes in a row and mark them with the numbers 1 to 7. Add 100 ml tap water to dish 1 and add 100 ml of the liquid detergent to dish 7.
- Prepare the solutions for dishes 2 to 6:
- Mix 180 ml tap water and 20 ml liquid detergent in a beaker. The concentration of the liquid detergent in this beaker is 100 ml/l. Transfer 100 ml of the solution from the beaker to dish 6.
- Pipette 20 ml of the remaining 100 ml to a clean beaker and add 180 ml tap water so that it contains a total of 200 ml. The concentration of the liquid detergent in this beaker is 10 ml/l. Transfer 100 ml of the solution to dish 5.
- Pipette 20 ml of the remaining 100 ml to a clean beaker and add 180 ml tap water so that it contains a total of 200 ml. The concentration of the liquid detergent in this beaker is 1 ml/l. Transfer 100 ml of the solution to dish 4.
- Prepare the solutions for dishes 3 and 2 in the same way.
- **Take care! Always rinse the pipette and beakers with tap water after use so that no higher concentrated solution is transferred to a lower concentrated solution.**
- The concentration of liquid detergent in the series of dishes is now as follows:
  Blank sample; 2. **0.01 ml/l**; 3. **0.1 ml/l**; 4. **1 ml/l**; 5. **10 ml/l**; 6. **100 ml/l**; 7. **1000 ml/l**.
- Leave the cress in the dishes for a period of 5 to 7 days in normal light. Record your observations. Add tap water as necessary to replace any water that evaporates, so that the volume of solution in each dish remains at its original level.

Disposal

- Pour the detergent solution down the sink and put the cress dishes in the waste bin.

Source of experiment:
http://www.henkel.com/com/content_data/106612_4.8.2_Sustainable_washing_for_a_clean_environment_Chemistry_for_Advanced.pdf

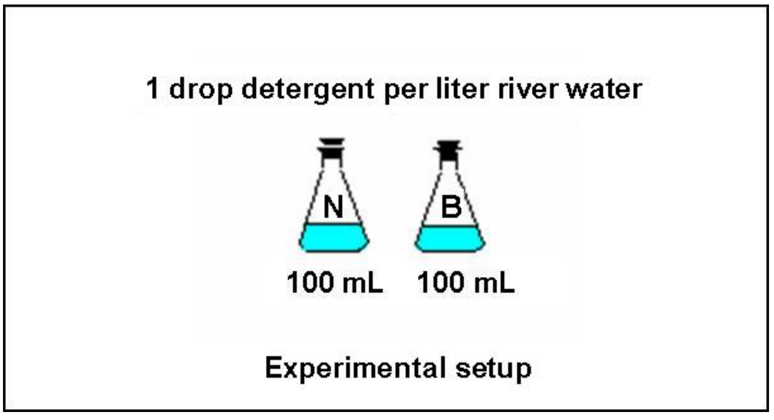
Regarding Worksheet 17, Part 2:

Apparatus and materials

- 2 Erlenmeyer flasks (200 ml) with stoppers
- hotplate
- beaker (500 ml)
- beaker (50 ml; with watch glass as a cover)
- glass rod
- graduated cylinder (100 ml)
- graduated pipette (1 ml)
- graduated pipette (10 ml)
- pipette filler
- felt-tip pen
- liquid detergent for colored fabrics
- river water

Procedure

- Pipette 10 ml river water into a 50 ml beaker and use the glass rod to add 1 drop of the liquid detergent to the beaker. When the drop has dissolved, transfer 1 ml of the solution to an Erlenmeyer flask, add 99 ml river water and label the flask "N" (= non-boiled sample). Stopper the flask firmly.
- Heat a beaker containing 200 ml river water on the hotplate until it boils. Allow the water to cool, then transfer 10 ml to a 50 ml beaker and use the glass rod to add 1 drop of the liquid detergent. When the drop has dissolved, transfer 1 ml of the solution to an Erlenmeyer flask, add 99 ml boiled river water and label the flask "B" (= boiled sample). Stopper the flask firmly.
  Caution! Each time you reuse a piece of apparatus, first rinse it carefully with tap water.
- Observe the foam formation in the flask over a period of 3-7 days. To do this, shake the two flasks simultaneously 10 times, as equally as possible, while holding them upright, then observe and compare the foam covering the two solutions.



Disposal

- Pour the wash liquid down the sink.

Source of experiment:
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-fibres

Learning aim:
Students familiarize themselves with the biodegradable fibres and discussed the possibility for their uses in textiles.

Material:
Experiments:
A) Synthesis of calcium alginate threads
B) Synthesis of polylactic acid threads

Suggestions for use:
for experiment A):

- make sure the process for preparing the syringe is followed closely, otherwise the needle will clog up with a calcium alginate plug
- a simpler setup can be obtained by pressing the sol into a beaker filled with calcium chloride solution
- calcium alginate threads are used for wound dressing

for experiment B):

- polylactic acid is used as suture material, and will be broken down after a certain time by the body

Activity 3.10: The dream fibre/detergent

Learning aim:
Students learn to use the structure-property-knowledge obtained so far. Along the lines of STS approaches, they use logical reasoning skills to argue hypothetically which characteristics should be combined to generate the perfect fibre/plant.

Material:
Results of activities 3.1 - 3.9

Suggestions for use:

- Students can assess desirable and problematic properties of fibres and textiles presented so far
- They can consider additives and production methods, working conditions and sustainability regarding manufacture and decomposition of different washing detergents and fibres, etc.
- Students should work in a team to exchange ideas and discuss different approaches.
- Finally, the students should present their dream fibre/ dream detergent to the class.