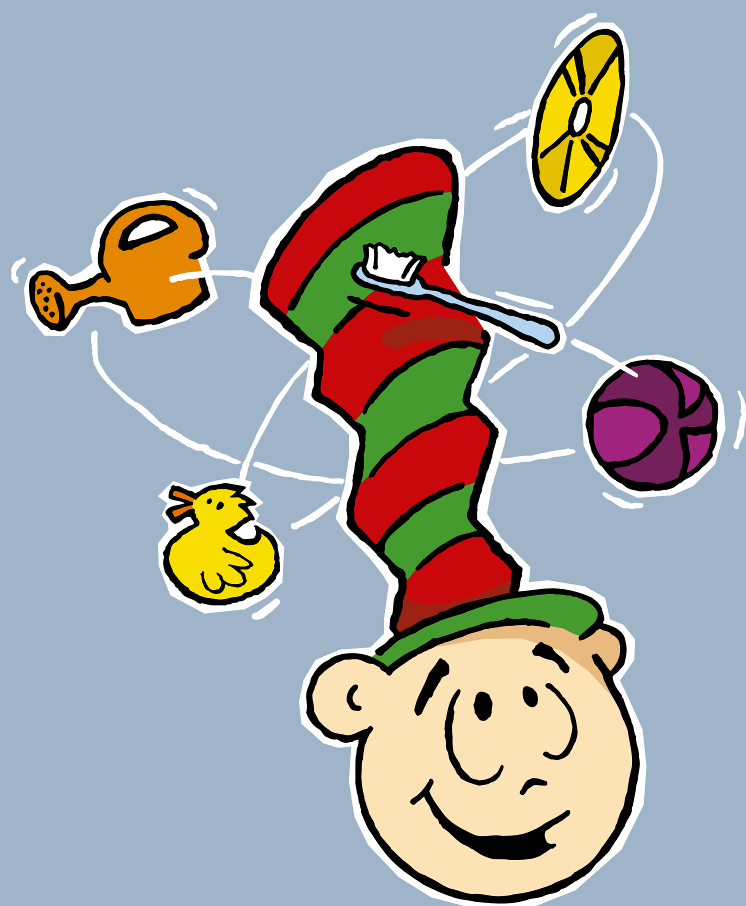

TEACHER'S BOOKLET

TO ACCOMPANY

"OLLY'S COOL BOX OF PLASTICS"

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Why deal with plastics at primary school?

Did you know that small plastic granules in diapers ensure that babies remain dependably dry? Do you know the difference between a water-soluble and a "normal" plastic film? And have you ever produced plastics – such as a foamed plastic – on your own?

Plastics are part of our everyday life; we find them in toothbrushes, telephone handsets, and seat pads. We use them quite normally in the kitchen, in the car, for communication, and for packaging. As insulating material or window frames made of plastics, they reduce our heating costs. Plastics have become everyday essentials and feature in state-of-the-art applications for environmental protection: from solar panels to windmills and membranes for wastewater treatment technology – polymers are needed everywhere. "Polymers" is the scientific term for plastics and is derived from the Greek words 'poly' (= many) and 'meros' (= part).

The purpose of "Olly's Cool Box of Plastics" is to present the varied and different characteristics of plastics in order to make them more understandable to children.

Purpose of experiments

Often, scientific phenomena still amaze school-age children who are keen to explore their world and grasp new things in a largely playful fashion. This natural childish curiosity should be nurtured, as new studies on development and learning psychology show that dealing with scientific phenomena in early childhood paves the way for a better understanding of technology and science in adulthood.

Experimental working and exploring is usually planned for science teaching in secondary education; hence the limited availability of teaching material for the basic science lessons in primary schools. "Olly's Cool Box of Plastics" is a helpful component of scientific education for kids of primary school age. The experiments assembled and described in the toolkit can be used to familiarise primary school children with the "plastics" topic. Experimenting independently offers kids an opportunity to gain their own experience with this innovative and versatile material. The pupils can autonomously carry out almost all experiments in an easy and safe fashion; a key criterion when selecting the experiments. However, the experiments' level of difficulty varies: Experiments 1 (Just normal plastic films?), 2 (Where has the water gone?), and 5 (A pocket-size sewage plant) can be performed very easily and are therefore suited for all kids in the third and fourth form. Experiment 3 (Let's produce plastics) is somewhat more demanding, as the materials used need to be measured. For safety reasons, experiment 4 (Production of foamed plastic) should be presented by the teacher only, since it requires the use of boiling water.

"Olly's Cool Box of Plastics" also contains the materials and specific "tools" in the quantities needed for all experiments to be performed in group work in several classes. The German LGA, ("Landesgewerbeanstalt Bayern") has tested all experiments and materials, classifying them as safe and suitable for children.

However, this assumes compliance with all preventive measures while experimenting. Hence, please note that swallowing the materials should be avoided as should contact with mucosa. Proximity to open flames must be avoided. After carrying out the experiments, the pupils should wash their hands thoroughly. Moreover, all utensils used should be cleaned well after use. The jars and pots used for the experiments should no longer be used with foodstuffs. In general, the experiments should be carried out under your supervision only.

The workflow of the experiments is explained step by step in the students' booklet "Olly's Cool Box of Plastics". The book xplains every experiment in a child-oriented fashion. It can thus be used as a basis for school lessons, or by the pupils at home.

Risk Assessments for the experiments are include for teachers at the end of this work book.

BACKGROUND INFORMATION ON THE EXPERIMENTS

EXPERIMENT 1:

1

Just normal plastic films?

Before commencing these experiments please refer to the risk assessments.

This teachers' booklet also includes an annex with a set of experimental templates for students.

Just normal plastic films?
Plastic products feature a very wide range of characteristics. The selection of source materials and the subsequent processing steps have an impact on the characteristic profiles of the products. Every child has already come across the films used in this experiment at some point – as a shopping bag, plastic wrap, or packaging.

This experiment makes it very easy to understand that plastics may have different characteristics although look quite similar. After carrying out the experiment, the students may consider which film to use in a sensible fashion and when.

Learning target:
The pupils should learn that plastic films that are very similar in appearance may in fact have different characteristics in contact with water and soil.

Base materials:

› **"Normal" PE film (green roll):** Film made of polyethylene with low density (PE-LD); known as freezer bags. Coloured and printed, PE is also used for shopping bags, packaging and the like.
› **Water-soluble PVA film (blue roll):** PVA stands for polyvinyl alcohol. PVA film is suited for products used in watery environments, e.g. bath salts, disinfectants, and colouring agents. In hospitals, laundry bags made of PVA are used, preventing physical contact with the dirty laundry before being washed and disinfected.

The textile industry treats fibres with PVA before processing them (knitting, weaving etc.) in order to protect them against damage. Afterwards, it is easy to wash the PVA out of the finished product.

› **Film made of Mater-Bi® (biodegradable, red roll):** Film made of starch blend (a mix of starch and biodegradable plastics). After using, it is converted to compost by biodegradation, contributing to the fertilisation of the soil and the improvement of the soil structure. Mater-Bi® is used for bio waste bags, shopping bags, packaging, disposable cutlery, agricultural film, flowerpots, upholstery material, and sanitary products.

What needs to be considered when performing the experiment?
This easy-to-do trial is particularly appropriate as an introduction to experimenting.

The tools are simple:

› green roll = "normal" PE film
› blue roll = water-soluble PVA film
› red roll = biodegradable film (Mater-Bi®)

Since all films are transparent and colourless, they can easily be confused. It is therefore recommended to hand out the films one after another and to have them marked by the kids – as described in the experiment instructions – immediately after cutting the required pieces of film.

⚠ Safety advice
Make absolutely sure that nobody drinks the water in which the PVA film is dissolved! If it nevertheless happens inadvertently ensure the person drinks copious amounts of tap water! After contact with the eyes: flush eyes with plenty of water. Keep plate with dissolved film in a safe place not accessible to children. Please also refer to the Risk Assessments at the end of the document

What if ...?
... the PVA film does not dissolve in water?

› Used water was too cold. The PVA film dissolves best in lukewarm water.
› the films have been mixed up.
› Carry out the experiment once again.

... the Mater-Bi® film does not degrade in the earth?

› The films have been mixed up.
› Carry out the experiment once again.
› The compost or garden soil used was too dry or the ambient temperature too low. The microorganisms need a humid and warm environment to grow.
› You checked too early. The degradation process begins only after 3–5 days.

Explanation relating to experiment 1
Although the films look very similar, their behaviour in water and garden soil are completely different. Film 1 (green roll) changes neither in the water, nor in the garden soil. Film 2 (blue roll) dissolves in water, but remains unchanged in garden soil. And film 3 (red roll) does not dissolve in water, but changes in garden soil. It becomes porous and dissolves. If you leave it long enough in the garden soil, it is completely degraded by the existing microorganisms. The variable behaviour of the three films is due to the different molecular structures of the plastics used. In general, we can say that the closer the molecular structure of a substance is to the molecular structure of water, the more water-soluble it is; the more it resembles the structure of oil, the more oil-soluble it is. The film number 1 made of polyethylene changes neither in water nor in garden soil. Like oil, polyethylene has a molecular structure that prevents dissolution in water and is hence water-repellent. Polyethylene is also used to produce objects that may not dissolve in water (such as plastic bags, rain coats etc.).
Film 2 consists of PVA. Unlike polyethylene, PVA has water-soluble characteristics. It dissolves in water. However, the components of PVA are retained, as shown by the additional experiment. PVA films are used where substances are to be released slowly, e.g. toilet deodoriser blocks. Film 3 consists of Mater-Bi® which is a bio-plastic that when used is naturally degraded by microorganisms living in the compost and soil, yet it is water-repellent! Applications for such films include bio-waste bags (food and garden waste), shopping bags, and in agriculture as mulch films. They are also used as packaging material, e.g. bags and nets for weighing and packaging fruit.

Explanation relating to an additional experiment
Water evaporates with heat. The material which the water-soluble film was made of, remains as a thin layer on the plate after all the water has evaporated.

BACKGROUND INFORMATION ON THE EXPERIMENTS

EXPERIMENT 2:

Where has the water gone?

Before commencing these experiments please refer to the risk assessments.

What happens to the water?
Plastics are not only able to repel water, but also dissolve in it. This experiment shows that some plastics are even able to absorb water. These plastics are well known and can be found in everyday life in baby nappies (and other sanitary articles).

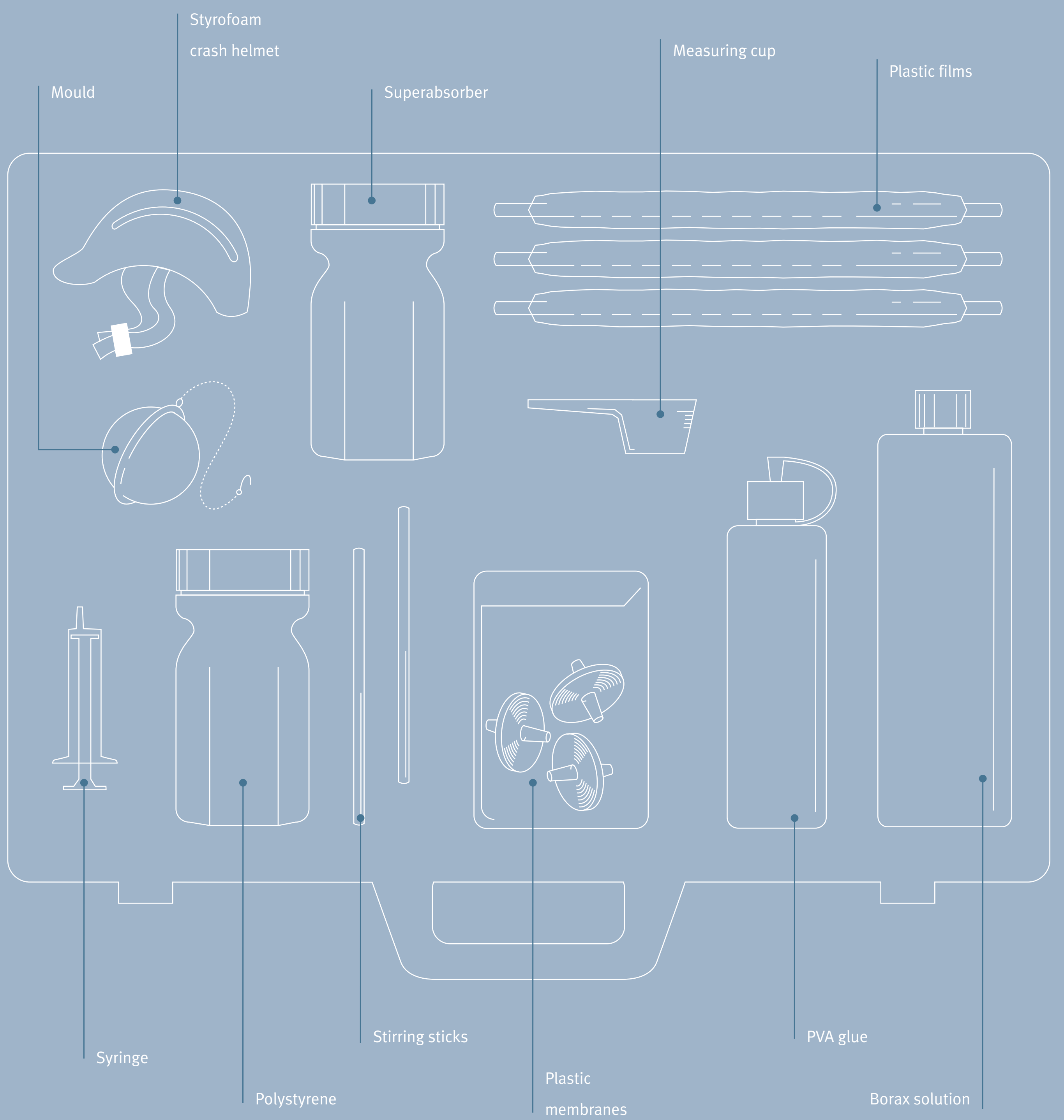
Learning target:
The pupils are supposed to discover the specific water absorbance capacity of plastics compared to other materials.

Base material:
Superabsorbers belong to the "family" of "functional polymers", as they are used in products that need their specific features. They are plastics with a high absorption and storage capacity. The basis of these characteristics is the chemical substance "sodium polyacrylate". Superabsorbers are used to manufacture sanitary products and baby diapers. Their absorption capacity is up to 60 times higher than that of cotton wool (cellulose).

What needs to be considered when carrying out the experiments?
This experiment is straightforward and not dangerous.

⚠ Safety advice:
Avoid any contact of the superabsorber with mucosa. After contact with the eyes: flush with plenty of water. Do not swallow! The superabsorber can be disposed of in the bin for residual waste after performing the experiment. Please also refer to the Risk Assessments at the end of the document.

Explanation relating to experiment 2
The different absorption capacities of the used materials mainly depend on the type and size of their surface: a stone has a flat surface that cannot be penetrated by water however there are exceptions such as pumice stone or certain types of clay. Their porous surface is able to absorb water, which settles in the tiny cavities.
Cotton wool is definitely more absorptive. It consists of many thin threads which together form a very large surface. Water settles on these threads, but is not retained. If you press cotton wool with your fingers, the water is released again.
Also in case of the plastics granules, the absorptive capacity depends on the surface. The granules consist of very long, densely wrapped plastic threads. Unlike the threads of cotton wool, the characteristics of these threads allow a combination with water. This compound is so strong that the water does not come off the threads any more.



BACKGROUND INFORMATION ON THE EXPERIMENTS

EXPERIMENT 3:

3

Let's produce a plastic

Before commencing these experiments please refer to the risk assessments.

Let's produce a plastic

The objective of this experiment is to produce a plastic. One of the raw materials used is PVA glue. Like all glues, also this one is already a plastic. (Strictly speaking, an existing plastic is simply modified in this experiment.) The self-made modelling material has a variety of characteristics: it can be pulled apart like common modelling clay, but also extended like a rubber band. Moreover, it bounces like a rubber ball.

The toughness of the modelling material is determined by the concentration of the borax solution. The borax solution contained in the plastics box has a level of concentration such that the pupils always achieve a kneadable rubber mass as a result. This experiment helps children to understand how a new plastic with specific characteristics is developed. The plastic polyethylene, for example, is used as thin "soft" packaging film, as thick "hard" protective sheet, as a "soft" bag for carrying shopping or as a "solid" yoghurt cup.

Learning target:

The experiment will enable students to understand how plastics are produced and see that the characteristics of the produced plastic vary from the characteristics of the original materials.

Base material:

- Borax solution (4.5% sodium tetraborate decahydrate in water) is made of a borax powder that can be found in a similar form in detergents.

- PVA glue is – like all common glues – a plastic. It is solvent-free and produced specifically for children. Note: Due to its composition, the experiment will succeed only with the included PVA glue. If other glue types with other chemical composition are used, the desired results are likely to fail.

What needs to be considered when performing the experiment?

This experiment is more demanding than experiments 1 and 2, as the base materials used must be measured. However, the experiment succeeds regardless of slight variations from the recommended quantities.

⚠ Safety advice:

Based on EU directives in force since 2015, we are obliged to state all security advice – however unlikely the relevance may seem. Please also refer to the Risk Assessments at the end of the document.

H 360FD: Borax can compromise fertility; may damage the unborn child. (This applies to borax as a solid substance that may diffuse into the skin or be inhaled. Both do not apply in case of the borax solution.)

P201: Obtain specific instructions before usage. P308 + P313: In case of exposure or where concerned: seek medical advice/ support.

The solution and the modelling clay produced must not be swallowed. However, should this happen, ensure the person drinks copious amounts of water, induce vomiting, and summon a doctor. In case of eye contact: Rinse open eyes for several minutes under running water. Ensure medical treatment.

Thorough hand washing with soap is absolutely necessary after the experiment has been performed.

The produced plastic does not contain any preservatives. It may therefore dry up or become mouldy after some time. Therefore, please dispose of the substance immediately!

What if ...?

... the modelling clay does not get solid?

- an insufficient quantity of borax solution has been added. Add some more borax solution. If the modelling material still is not solid, perform the experiment once again.

Explanation of experiment 3

Due to the compound formed between the borax and the PVA glue, the substance becomes ever more solid while stirring. The result will be a rubber-like material.

The explanation for this phenomenon is to be found in the molecular structure of the two base materials. The basis of the glue is a plastic consisting of long molecular chains. In contrast, the borax solution is composed of shorter molecular chains that – like the rungs of a ladder – are able to connect the long chains of the glue. This combination reduces the flexibility of the long molecular chains and the mixture becomes viscous. Increasing the concentration of the borax solution would create further connections between the long molecular chains thereby making the mixture more solid and reducing its elastic properties.

BACKGROUND INFORMATION ON THE EXPERIMENTS

EXPERIMENT 4:

Let's produce a foamed plastic

Before commencing these experiments please refer to the risk assessments.

Production of foamed plastics

The purpose of this experiment is again to produce plastics. A foamed plastic children know as packaging material. It is therefore particularly fascinating for kids to observe the production process.

Foam plastics are suitable for impact protection in many applications. They protect fragile objects against impact and pressure, as it is able to yield, although it is solid (important e.g. for protective helmets for bicycles). Thanks to its low weight, foam material is often used as packaging material. Moreover, foam plastic can be used as an insulating material.

"Olly's Cool Box of Plastics" contains a miniature protective helmet made of foam plastics. You can use it to fix an egg in it by means of the attached ribbons. To demonstrate the function of protective helmets, let the protected egg fall on the floor from a height of about one metre. Normally, the egg remains intact. As part of the road safety education, this will help you to motivate your students to wear protective helmets when biking.

Learning target:

The students will understand how foamed plastics are produced by changing the base material of expandable polystyrene (EPS).

Base material:

The base material for foamed plastics is a colourless liquid made from crude oil. A chemical reaction (polymerisation) results in a solid substance. To convert it to foam plastics, the foaming agent pentane/ isopentane is added. This creates the glass-like pellets which can also be found in "Olly's Cool Box of Plastics".

What needs to be considered when performing the experiment?

Since this experiment requires boiling water, you should carry it out as a teacher's experiment. Immerse the mould filled with EPS (abbreviation for "expandable polystyrene") in the boiling water. The ball must be fully immersed the whole time.

Make sure the filled mould remains in the boiling water for four minutes; do not use an electronic water boiler with automatic switch-off.

To simplify the removal of the resulting foam plastic ball, please ensure the following: fill the mould as exactly as possible to one third with the EPS and cool the resulting foamed ball in cold water immediately after it is removed from a hot mould.

⚠ Safety advice

Based on the EU directives in force since 2015, we are obliged to state all security advice – however unlikely the relevance may seem. Please also refer to the Risk Assessments at the end of the document.

EUH018: In order for the polystyrene to foam, the EPS balls contain pentane/isopentane. As a consequence, its usage may cause the development of an explosive/ inflammable steam-air mixture.

P210: Heat/sparks/open flames and hot surfaces must be strictly avoided. Do not smoke during usage.
P233: Keep container tightly closed.
P243: Take measures against electrostatic charge.
P403+P235: Store in a well ventilated place.

What if ...?
... the polystyrene does not foam?
... the balls remain unchanged?

- Water is not hot enough. For foaming, the water must boil.
- EPS already stored too long. Consider expiration date on the container.

... moulded polystyrene part crumbles?
... no compact moulded part develops?

- The filled EPS was not left long enough in the water, however some foamed plastic may already visible.

Explanation of experiment 4

If the moulded part with the polystyrene pellets remains long enough in boiling water, foamed plastics develops. This is a white material that is very light. Foamed plastics mainly consist of air. But how do you get the air into the plastics pellets? This takes place in two steps: first, the plastic balls containing a foaming agent (pentane) are foamed with heat. This happens in boiling water. After cooling down and demoulding, air invisibly absorbs slowly into the foam displacing the pentane. You will realise that the foam is still very soft after unmoulding, however it will substantially harden over the next couple of hours.

The difference is similar to a ball pumped well or poorly with air. Now, the foam is better able to absorb pressure and protect against cold and heat. This is why you can find foamed material in protective helmets for bicycles, insulated containers, and many packaging materials.

4

BACKGROUND INFORMATION ON THE EXPERIMENTS

EXPERIMENT 5:

A pocket-size sewage plant

Before commencing these experiments please refer to the risk assessments.

A pocket-size sewage plant

Plastics help to protect the environment and save resources. Without plastics, it would be impossible to efficiently use alternative energy sources sun, wind, and water. But plastics are also important for water treatment. This experiment will show the children how water treatment works.

Learning target:

The kids will see how the membrane made of plastics is able to clean the wastewater and far more efficient then the filters they know.

Base material:

Filters are characterised by pores that are permeable for the filtrate. They can be used e.g. to filter out parts that are dissolved in the water and bigger than the pore openings. Membranes can be distinguished from other filters by the very small diameter of their pores, which are impenetrable even for very small parts dissolved in water. Ideally, the pores are small enough to be permeated only by water.

What needs to be considered when performing the experiment?

This experiment is basically uncomplicated. However too many large dirt particles can clog the plastic membrane thereby preventing the water from being filtered through it. In this case, a new membrane needs to be used.

Explanation of experiment 5

Only the fine pores of the membrane were able to really clean the water in the experiment. In everyday life, membranes such as these are used to purify water and air where even the slightest contamination occurs. Thanks to their fine pores, some membranes are even able to remove the tiniest bacteria and viruses from contaminated water. In many production processes, cleanness is of critical importance and here membranes provide a vital role. They are used for example in drugs manufacture and In the computer industry where even a dust particle can cause problems as it may damage the fine structures on microchips. Membranes are also employed for filling beverage bottles where they make sure that for example milk, lemonade and other beverages are filled in the bottles free of any impurities.

In sewage plants and in industrial plants, membranes produce clean water.

In addition, membrane technology is applied in our clothes. So-called breathable jackets, pullovers, or underwear utilise these tiny pores so that perspiration passes to the outside. Germany is an international leader in the field of membrane technology which has brought far-reaching sanitary and environmentally relevant benefits.

List of chemical materials in "Olly's Cool Box of Plastics"

Classification by GHS: Globally Harmonised System of Classification and Labelling of Chemicals (arranged in alphabetical order).

PVA glue	no labelling as per GHS
Borax solution	Danger H 360FD: Borax may compromise fertility; may damage the unborn child. (This applies to borax as a solid material that may diffuse in the skin or be inhaled. Neither of the two applies in the case of the borax solution.)
EPS	no labelling as per GHS
Mater-Bi® film	no labelling as per GHS
PE film	no labelling as per GHS
PVA film	no labelling as per GHS
Superabsorber	no labelling as per GHS

The materials required for "Olly's Cool Box of Plastics" have been tested for potential health effects and classified as appropriate by the Landesgewerbeanstalt Bayern (LGA). Where complying with the general safety measures stated in the booklet e.g. do not swallow materials, do not use cutlery for the experiments, wash your hands after experimenting, performing the experiments is considered to be very low risk. We recommend that you also refer to the Risk Assessments at the end of the document.

Useful UK telephone numbers

Nevertheless if medical questions arise while experimenting, contact the numbers below to get support:

Emergency Numbers

Fire: 999
Police: 999
Ambulance: 999

Non-Emergency Numbers

NHS 111 service: 111

For general information and feedback:

British Plastics Federation:
020 74575000
+44 20 74575000 – From outside the UK
Or mail: info@bpf.co.uk

Germany

Tel: 112

Belgium

Emergency Numbers

Emergency services: 112 (from mobile telephones)

Non-Emergency Numbers

For general information and feedback:

PlasticsEurope: +32 2 676 1730
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