The way of the dragon: chemistry for the youngest

In Sweden there lives a small, green dragon called Berta, who invites young children to join her adventures in Dragon Land – all of which are about chemistry.

By Anna Gunnarsson

At the NAVET Science Center in Borås, Sweden, we created Berta the Dragon as a way of introducing science to very young children (4-8 years). The dragon character is a hand puppet who teaches children about the wonderful world of chemistry through experiments, using Berta's own stories as a starting point. The first stories about Berta were so popular that they were published in 2010 as a book, *Berta's Book of Experiments: Exciting chemical fairy tales from Dragon Land*. A second Berta book has since followed.

The aim of all Berta's activities is to promote the understanding and use of chemistry in real life, with everyday materials that are familiar to everyone. The materials are non-toxic and most of them are easy to find on grocery shelves, so children can handle them without complicated or expensive laboratory equipment.

The experiments cover many different areas of chemistry – such as solutions, gases, and acids and alkalis – and are all designed to be done not just in science centres or schools, but also at home.

Portrait of Berta.

Image courtesy of Karin Södergren

Photo of Berta

Image courtesy of Adam Danielsson

Children doing chemistry experiments.

Image courtesy of Joakim Lenell

What makes a good Berta activity?

All the Berta activities have been tried out with young children many times over several years to ensure that they are interesting and easy to do. When we choose activities for Berta and her young experimenter friends, we always look for these key elements:

- Safety: can the children safely experiment with the ingredients, *even if some of them happen to end up in their mouths* (it doesn't matter if they taste bad – but they have to be edible to find this out)?
- Child appeal: are the results fun, clear enough to see or touch, and a bit unexpected or even amazing?
- Exploration: does the chemistry raise interesting questions, and will it lead to new experiments and experiences?

There also needs to be an element of interacting with other people, as this is often the way we learn the most. Some of the experiments are most successful when carried out with a large group of children gathered around an activity, discussing, exploring and pouring in ingredients together as we go along; others work best with pairs of children or smaller groups.

In this article we describe three popular activities that are typical of Berta's style. While the experiments are different all three share the same characteristic for making the familiar intriguing.

REVIEW

- ☑ **Chemistry**
- ☑ **Physics**
- ☑ **Ages 4-12**

Usually chemistry lessons are not part of primary-school education, especially in earlier years. This paper illustrates some novel and interesting activities and offers an alternative way to teach chemistry that any pupil could participate in and understand. I don't think that many teachers in Cyprus include chemistry in the first three or four classes of the primary school education. This article could form the basis for changing this tradition and call on young students to participate in fun and inspiring lessons. It is important, however, that these activities are not used only as show-and-tell experiments. Teachers should be well prepared for the discussion that will follow. They should be prepared from the pedagogical perspective of the lesson. For example, the questions posed by the teacher, the discussion held among the pupils of the same group and the explanations that they develop (with the help of the teacher) is the most vital part of the experiment. These are not provided here, but are left to the teacher to prepare.

Christiana Th. Nicolaou, University of Cyprus

Citrus fruits

Image courtesy of Roger Public domain imge / Wikimedia Commons

Activity 1: Floating bubbles

Age-group: 4-8 years

Materials

- 4 Tbsp sodium hydrogen carbonate ($NaHCO_3$ also known as bicarbonate of soda)
- Water - enough to fill the container with a 2cm high volume
- 2 Tbsp citric acid
- Ready-made soap bubble mixture
- Small aquarium or similar container with straight sides
- Large piece of paper to cover the container

Procedure

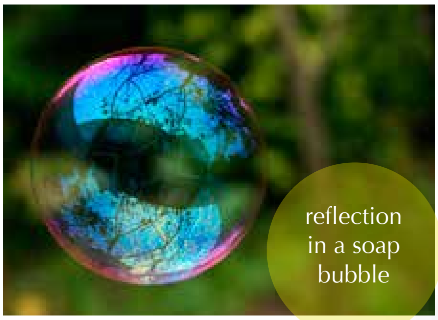
1. Mix 4 Tbsp of sodium hydrogen carbonate with 2 Tbsp of citric acid.
2. Spread the mixture over the bottom of the container.
3. Pour some water over the mixture: where does the sound come from?
4. Cover the top of the container with paper: why is it important to do that?
5. Wait for 3–4 min.
6. Blow soap bubbles while you wait – the kids can do this too. What kind of gas do we fill soap bubbles with when we blow them? What do we know about the gas that comes out of our mouths?
7. Lift the paper from the container and blow bubbles above it, letting some fall into the carbon dioxide gas formed. Why do the bubbles seem to float well above the liquid and not fall to its surface?

Impact of a drop of water

Image courtesy of Roger McLassus/ Wikimedia Commons

About what happens

When water is added, the sodium hydrogen carbonate and citric acid dissolve in it and start reacting. Carbon dioxide gas is produced, which makes a distinct fizzing sound as the gas spreads through the container.



reflection in a soap bubble

Image courtesy of Trodel / Flickr

Carbon dioxide gas is denser than the surrounding air so it doesn't all float away, but there is still a chance of it escaping due to turbulence in the air (and it's really hard to see where it goes as it has no colour). This is why we put the paper over the container and keep it there until all the gas is formed and everything is ready for the bubbles. The soap bubbles contain air, so they have a lower density than the carbon dioxide gas; this means they float on top of the gas, showing that it's there and where it ends.

Bubbles floating well above the liquid.

Image courtesy of Emelie Gunnarsson

If a soap bubble floats for a while, you'll see that it slowly increases in size. This is because carbon dioxide gas travels into the bubble faster than air travels out. This also makes the bubble heavier, and it will eventually sink to the bottom of the gas layer.

Idea for a follow-up experiment

What will happen if carbon dioxide gas is formed inside a plastic bag?

Berta the dragon with citrus fruits.

Image courtesy of Emelie Gunnarsson

Different citrus fruits behave differently when dropped in water.

Image courtesy of Emelie Gunnarsson

Activity 2: Taking citrus fruits for a swim

Age-group: 4-8 years

Materials

- 1 lime
- 4 other citrus fruits, e.g. lemon, grapefruit, orange, tangerine etc.
- Knife for peeling fruit
- Large transparent container (at least 20 cm deep)

Procedure

1. Fill the large container with water.
2. Discuss what might happen when the fruits are dropped into the water.
3. Let the fruits 'go for a swim'. Why are some of them floating better than others?
4. Peel the fruits very carefully - so that the peel stays in one compact piece – and remove all the white pith from the fruits.
5. Discuss what might happen when the fruits are dropped back into the water without their peel.
6. Let the fruits 'swim' again, and watch what happens. Discuss what has changed and why this might be.
7. Pick up each fruit and put its 'life jacket' (its own peel) back on, then let them go back into the water. What effect does the peel have?
8. Discuss what will happen when the peels are dropped into the water without the fruit – then do this, and watch.

About what happens

Most whole citrus fruits float in water, but this changes once their peel is removed. The intact fruits float because of the large amounts of air held in the spongy white pith, which gives them a lower density than the peeled fruits. If the peel is removed in one piece, we can put it on and take it off like a life jacket, and it becomes obvious that it is the peel that is making the difference to the fruit's buoyancy.

The difference between lemons and limes is interesting in this respect. Both fruits have a density very close to that of water. However, limes always sink as they have a density slightly higher than water (because

Green citrus fruits have very little white pith, so sometimes they fall to the bottom of the container.

Images courtesy of Emelie Gunnarsson

Oranges have enough white pith to float when they are dropped into water.

they have hardly any white pith), whereas lemons sometimes float and sometimes sink, depending on how much pith the fruit contains.

Idea for a follow-up experiment

What will happen if we try other fruits and vegetables in the same way?

Activity 3: Droplet drama

Materials

- Vegetable oil
- 1 Tsp sodium hydrogen carbonate (also known as bicarbonate of soda)
- 1 lemon
- 100 ml red cabbage juice[w1] or blueberry juice
- Tall, narrow vase
- Drinking glass
- Spoon

Children doing experiments with Berta.

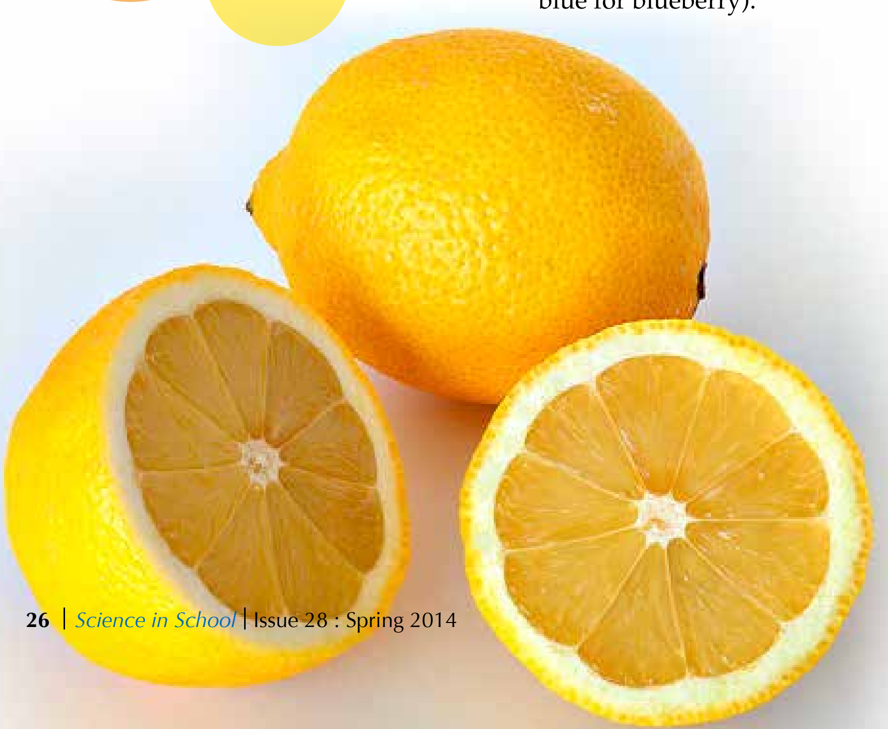
Image courtesy of Joakim Lenell

Sodium bicarbonate, or sodium hydrogen carbonate

Image courtesy of Thavox, Wikimedia

Procedure

1. Put 1 Tsp of sodium hydrogen carbonate into the vase.
2. Pour vegetable oil on top of it to fill about two-thirds of the vase.
3. Watch the vase closely. What kinds of bubbles are rising to the top? Where do they go after reaching the surface?
4. Mix 100 ml of juice with a little water – just enough to show its real colour (purple for cabbage, blue for blueberry).
5. Discuss what colour the juice might turn if we make it sour using lemon juice.
6. Squeeze a little lemon into the juice and stir. Why does it change colour?
7. Pour some of this juice mixture into the vegetable oil. What happens to the juice droplets? How do they move? What about the transparent bubbles that are formed?
8. Look at the juice at the bottom of the vase. What colour is it? How does it change after a while?
9. If the reaction slows down, put some more lemon juice into the vase.



Lemon

Image courtesy of André Karwath aka / Wikimedia Commons

About what happens

The sodium hydrogen carbonate at the bottom of the vase contains some air trapped in the powder. When the vegetable oil is poured on top of it, the air forms bubbles that rise to the surface.

Red cabbage and blueberries contain natural dyes that are sensitive

Image courtesy of Lemone / Wikimedia Commons

Olive Oil

to changes in acidity, and they both become red when mixed with lemon juice, which is acidic (pH 3). The red juice droplets sink through the vegetable oil because they contain mostly water, which has a higher density than the oil. Once the acidic juice hits the sodium hydrogen carbonate, a chemical reaction takes place, producing carbon dioxide gas and making the juice less acidic. (Sodium hydrogen carbonate is alkaline when dissolved in water, so it neutralises the acid when they react together.)

The larger bubbles of carbon dioxide gas then rise quickly to the surface of the oil, while smaller ones gather on the surfaces of the juice droplets, making these float upwards too. Once the gas is released at the top, the juice droplets sink again to the bottom where they pick up more gas from the reaction, and rise again. They also become a bit more alkaline each time, which we see as a change in colour back towards blue or purple.

Idea for a follow-up experiment

See how many different colours you can get just by adding different amounts of lemon juice and sodium hydrogen carbonate to blueberry and/or cabbage juice.

References

Gunnarsson A., Södergren K. (2010) Berta's Book of Experiments: Exciting chemical fairy tales from Dragon Land. Navet and P&K (The Swedish Plastics and Chemicals Federation), Sweden. ISBN: 978-91-85107- 22-3 (available in Swedish, English and Norwegian)

Gunnarsson A., Södergren K. (2013) Berta´s New Chemistry Adventures. Navet and IKEM (Innovation and Chemical Industries), Sweden. ISBN: 978-91-85107-23-0 (available in Norwegian and Swedish)

Image courtesy of Joakim Lenell

Teachers observing the bubbles in the vase at the end of the experiment.

Web reference

w1 – You can download the recipe for how to extract cabbage juice from the *Science in School* website at: www.scienceinschool.org/2014/issue28/berta_dragon#resources

Resources

To learn more about the NAVET Science Center, see: www.navet.com. The website is mostly in Swedish, but some parts are also in English.

To see more Berta experiments, visit her website at: www.draknet.se or her Facebook page: www.facebook.com/berta.drake?fref=ts (both in Swedish).

To find out more about the use of cabbage juice as a pH indicator, visit: http://chemistry.about.com/od/acidsbase1/a/red-cabbage-ph-indicator.htm

For more activities on acid/base reactions, visit: www.kidsplayandcreate.com/what-hapens-when-you-mix-acid-with-a-base-fun-and-easy-acid-and-base-science-projects-for-kids/

If you found this article useful, you may like to explore the other teaching activities published in *Science in School*. See: www.science-inschool.org/teaching. Otherwise you can also browse through the rest of the *Science in School* articles for primary school. See : www.scienceinschool.org/primary

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Anna Gunnarsson works at NAVET Science Center in Borås, Sweden, as a teacher and project manager. She is responsible for the development of activities in chemistry for young children and other projects in science, mathematics and technology, nationally and internationally.

To learn how to use this code, see page 57.

Chemistry

Physics