Figure 1
Getting hands-on investigating white powders

Engaging activities on properties and changing materials

Andy Markwick and **Kevin Watts** explore properties and changes of materials, introducing some ideas for chemistry activities

Learning chemistry through hands-on activities can be extremely engaging for children and provide important links between science and everyday familiar materials. It is therefore important that, as teachers, we provide pupils with a range of chemistry activities that explore how products are made and link this with how they are used. This article shows how children can explore several exciting and safe chemical reactions in a practical way. The activities are considered separately with a method, a scientific explanation and links to uses. The detailed science explanations are intended to support teachers' subject knowledge and so build confidence to teach science.

At key stage 1 (ages 5–7) the National Curriculum for England requires children to begin an exploration of the physical properties of materials, such as hardness, flexibility, lustre, transparency and absorbency, and linking these to potential uses is strongly emphasised (DfE, 2015). At key stage 2 (ages 7–11) physical properties are described as reversible changes. The key ideas developed include making solutions, evaporation and changes of state. It is also in year 5 (age 9–10) when chemical reactions are introduced. Children are expected to explore how new materials (products) are formed, with chemical changes being described as '*not usually reversible*' to distinguish them from physical (i.e. reversible) changes. Examples provided in the non-statutory guidance are burning, rusting and the reaction between acid and carbonate. The same guidance also suggests that children might '*research and discuss how chemical changes have impacted upon our lives*' and provides cooking and the use of polymers as examples to consider.

However, very little guidance is provided for teachers on potential and appropriate hands-on activities that would develop children's understanding of what chemistry is and how important it has been in shaping our modern society.

Key words: Chemistry · Hands-on · Enquiry

Investigating white solids

Before chemical reaction activities are introduced, children are asked to observe the interaction of water with three different white solids (salt, flour and 'fake snow' or sodium polyacrylate). Children learn how to observe closely and describe what they see.

Give each group of pupils a small amount of the powders, each in a small container.

Using a dropping pipette, the children carefully add some water to the first solid drop-by-drop, keep adding water until there are no further changes (Figure 1), and then record their observations in a table (Table 1). This is repeated for each solid.

What you can expect to see

Responses will vary, depending on children's prior knowledge and experiences. This is a great opportunity for the children to use descriptive language and begin to apply some science vocabulary. However, children should notice that the salt (A) dissolves, flour (B) is insoluble and forms a suspension, and 'fake snow' (C) absorbs the water and increases quite dramatically in volume. 'Fake snow' is a polymer called sodium polyacrylate. This substance is used in babies' nappies. It can absorb up to 300 times its mass of water.

To help children visualise dissolving and absorption the following activities can be useful. This can lead onto a whole host of nappy-related enquiries!

Table 1 Example of a results table

Solid	Observation	Explanation
A		
B		
C		
The following vocabulary may help you: solute, solvent, soluble, solution, insoluble, suspension, absorb, swell, expand.		

Modelling dissolving

Dissolving is a very challenging concept for children to understand. Asked what happens to sugar in a cup of tea, quite often they will tell you it 'disappears'. How can we help the children to make sense of this abstract concept?

What you need

- **6 x A4 white cards (you can write salt on each) – these represent the salt crystals. For greater challenge, cards can be labelled NaCl, or Na and Cl to represent the individual sodium and chloride ions.**
- **12 x A4 blue cards (you can write water on each) – these represent water molecules. For greater challenge each card can be labelled H_2O.**

What to do

1 Ask six children to hold a white card and stand close together in a formation of two rows of three. This represents the salt crystals.

2 Ask six children with blue cards to remove one of the children with a white salt crystal card. They must circle the salt crystal and hold their blue cards outwards. This shows children that the salt is still there, but hard to see as it is surrounded by water molecules (Figure 2).

Modelling absorption

Children will have some idea of what it means for a substance to be absorbed but again we can help to consolidate this in their minds with a simple model.

What to do

1 Ask six children to hold a white card each and stand shoulder-to-shoulder in a straight line – they represent molecules of 'fake snow'.

2 Invite someone to be a water molecule (blue card) and squeeze into the 'fake snow' line of children. Repeat this with a further three water molecules. They should notice that the line gets longer – this represents the increase in volume of the 'fake snow' (Figure 3).

Teacher notes

These activities can be used to promote wider thinking. Consider asking:

- **How can the water be removed?**
- **Can the solids be recovered?**
- **Is this a reversible process, and how could this be modelled?**

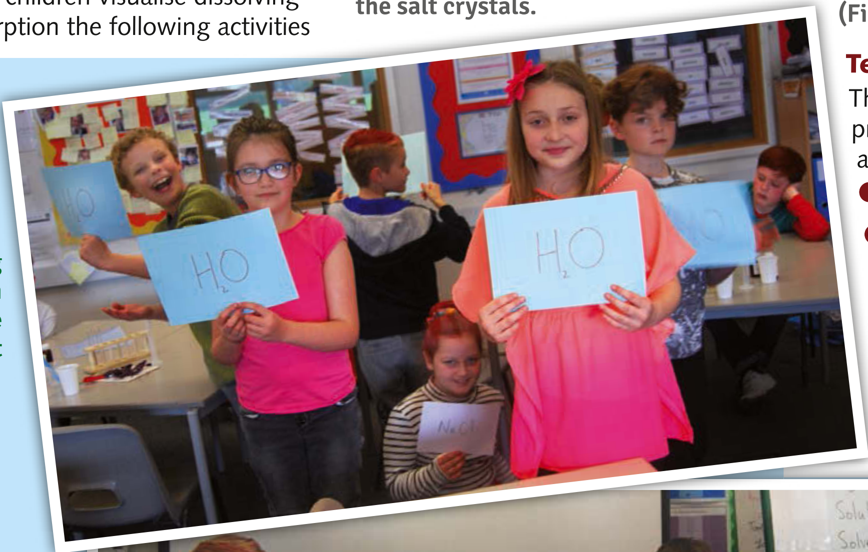

Figure 2 Children model dissolving to help them understand the concept

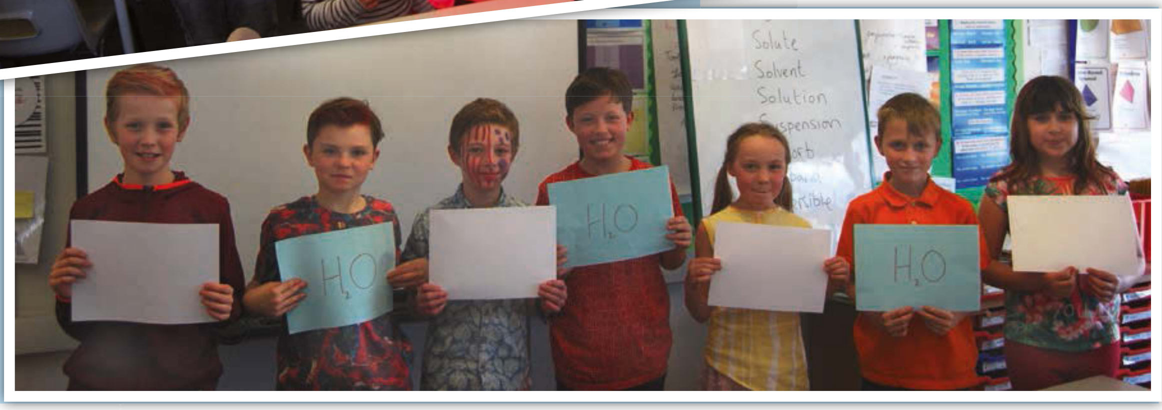

Figure 3 Modelling how absorption increases volume

Chemical reactions

The following activities provide opportunities for pupils to discover different types of chemical reaction and to learn how chemists use symbols to write chemical formulae.

Activity 1 Making calcium carbonate (limestone)

This activity links well to the year 3 'Rocks' topic. Children have looked at limestone; now they can make it.

What you need

- Limewater (calcium hydroxide solution) obtainable from a friendly secondary school.
- Straws and test tubes.
- It is advisable that children wear eye protection.

What to do

1 Place your straw into the test tube containing limewater.

2 *Very* carefully blow into the test tube. *Do not* suck!

3 Record your observations and explain what happened.

Teacher notes

Place no more than 5 ml of limewater in a test tube. Demonstrate how to gently blow through the straw into the limewater.

What's the science?

Exhaled air contains enough carbon dioxide to react with the limewater and produce calcium carbonate. Calcium carbonate is insoluble in water and therefore forms a precipitate (solid):

$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

This reaction is used to test for carbon dioxide.

Activity 2 Reacting an acid with a dissolved carbonate

What you need

- Red cabbage indicator – make this up first by chopping up a small amount of red cabbage into small pieces and stirring with 5 ml of water in a beaker.
- Sodium hydrogen carbonate (try to obtain pure $NaHCO_3$ as baking powder also contains other ingredients).
- Distilled vinegar (contains ethanoic acid, CH_3COOH).
- Syringes, pipettes and test tubes.

What to do

1 Using the syringe, place 10 ml of $NaHCO_3(aq)$ into a test tube.

Figure 4 Red cabbage indicator working its wonders

2 Pipette in 3 ml of red cabbage indicator and note what happens.

3 Using a fresh pipette, very slowly add 10 ml of $CH_3COOH(aq)$.

4 Record your observations and explain what happened.

Teacher notes

If children get vinegar in their eyes, wash out with plenty of water.

What's the science?

Red cabbage juice contains a group of coloured chemicals called anthocyanins. These chemicals change their colour depending on whether they are in acidic, alkaline or neutral environments:

- red = acidic
- blue = neutral
- green/blue = alkaline.

The red cabbage indicator is made with water (neutral) and will be a blue colour. When added to the $NaHCO_3$ (alkaline) it will change to a green or green-blue colour. Addition of CH_3COOH (acidic) produces a red colour and carbon dioxide gas is evolved. Ask pupils to suggest what gas they think has been formed (the clue is in the name carbonate). The formula for the reaction is:

$NaHCO_3(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + CO_2(g) + H_2O(l)$

(Note: g = gas and l = liquid)

If children add the vinegar carefully they may be able to produce red, blue and green layers, that is acid, neutral and alkaline (Figure 4).

Activity 3 Reacting an acid with a solid carbonate

What you need

- Baking powder ($NaHCO_3$).
- Distilled vinegar (contains ethanoic acid, CH_3COOH).
- Red cabbage indicator (made up in advance as above).
- Spatulas, pipettes and beakers.

What to do

1 Add 4 heaped spatulas of baking powder ($NaHCO_3$) to a beaker.

2 Pipette in 3 ml of red cabbage indicator. Note what happens.

3 Using the same pipette as in the last experiment, add 3 ml of $CH_3COOH(aq)$.

4 Record the observations and add more acid if you want to.

Teacher notes

This reaction should be familiar as the 'volcano reaction'. The reaction is the same as that in Activity 2, but instead of using a solution of $NaHCO_3$ the solid is used.

The production of carbon dioxide gas from baking powder ($NaHCO_3$) is used in baking. Baking powder thermally decomposes when heated and releases CO_2. It is the CO_2 gas that produces the holes in breads and cakes.

Activity 4 Making slime (or a polymer if we want to use the big words!)

What you need

- A plastic cup containing 10 ml PVA glue.
- Borax (obtainable from a chemical supplier).
- Food dye.
- 3 ml pipette.

What to do

1 Add an equal volume of water to 10 ml PVA glue in a cup and stir it well.

2 Using a 3 ml pipette, transfer 9 ml of borax solution to the PVA solution and stir.

3 Record your results.

4 Add 6 drops of food dye and mix.

5 You may handle with care (wear gloves).

Figure 5 Making slime can support powerful science as well as being great fun!

Teacher notes

Borax is now thought to have a very low risk to pregnant women, yet is considered safe to use (see www.cleapss.org.uk). The best results are given if the food dye is added after the borax.

What's the science?

PVA is a polymer containing extremely long chains of vinyl acetate molecules joined together. When borax is added they join the polyvinyl acetate molecules together, forming a structure that looks like a ladder or netting. These additional cross-linking bonds change the properties of the PVA from a viscous liquid into a rubbery solid (Figure 5).

Polymers are everywhere, from plastic bags, to chairs we sit on in school to even our clothes. Children may be familiar with names such as polythene, polyvinyl chloride (PVC) and polyester.

Cross-curricular links

With ease, each of these activities links with the wider primary curriculum. For a writing challenge, imagine visiting another planet: the only life that exists is made of slime. What would it look like? How would it move, feed, reproduce and communicate? When it comes to volcanoes, consider links with history and geography. The opportunities to develop maths skills are in abundance.

Most importantly, these activities offer pupils the opportunity to engage with challenging concepts and scientific vocabulary while having fun! As teachers it can be tempting to shy away from complex language but our experience is that giving it a go encourages and enthuses the children as they strive to work like scientists.

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Reference

DfE (2015) *National Curriculum in England: science programmes of study*. London: Department for Education.

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