CoCoMicro Book

ROYAL SOCIETY OF CHEMISTRY

Friends of Cotteridge Park

DISCOVER MATERIALS

Welcome to your CoCoMicro Booklet

It contains fun science activities you can explore at home.

The experiments in this booklet take you on a journey to learn about the materials around you. You can look at them close-up, through a microscope lens or think about atoms which are the building blocks that make up all materials. You can investigate bubbles including what makes a bubble, have a go at making a gas or try to make your own fizzy rocket or bath bombs.

We hope you have fun exploring this booklet of experiments that investigate the materials around you. The experiments use things found at home or some may require supplies from the supermarket.

Learn more about chemistry with the **Royal Society of Chemistry** www.rsc.org

Learn more about materials with Discover Materials www.discovermaterials.uk

Learn more about events at Cotteridge Park with Friends of Cotteridge Park www.cotteridgepark.org.uk

EXPLORING MATERIALS

1 The materials around us

Materials Scavenger Hunt

Everything is made of a material. These materials include metals, plastics and glass. The choice of what to make an object out of depends on what it is going to be used for. If you have a cup of hot chocolate it may be contained in a mug.

The mug is probably made from clay (a ceramic material). This is used because it is easy to shape (when wet) and can be hardened. The ceramic mug can't let heat through very well (is a poor 'heat conductor') which means your hot chocolate stays hot and the outside is cold enough to hold.

Why not explore the materials that are used in your home or even go out for a walk, and look at the materials in your street or local park, and think of what materials things are made from and why those materials were chosen.

You will need:

- a clipboard
- a materials scavenger hunt sheet
- a pen or pencil

What to do

Take your scavenger hunt sheet, clipboard and something to write with and look around the house or go for walk and try to find something that is made of:

Wood / Metal / Plastic / Glass / Stone / A Composite (which is two or more materials mixed together)

Write down what you have found and why you think an object is made from their material.

You can photograph your completed sheet and upload to share with others on our Padlet page: https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac
Materials Scavenger Hunt video: https://youtu.be/QoRU0aWEs5s

Materials Scavenger Hunt

Was the scavenger hunt done inside or outside? ______________________

Find something made of	What have you found?	What is that object used for?	Why do you think it is made from that material?
Wood			
Metal			
Plastic			
Glass			
Stone			
A composite (two or more materials mixed together)			

You can share a photograph of your completed scavenger hunt on our padlet page:
https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

Take a closer look at surfaces

You will have found a lot of different materials in your scavenger hunt and they will probably have looked very different. The surfaces of these materials can be fascinating. It is time to look more closely by using the clip-on microscope lens in your box. This lens will make things look sixty times bigger, which lets you see a surface in a lot more detail, giving you clues into how a material was made or what it is used for. You will be able to take a photo of the surfaces by using a smartphone or tablet.

Clip-on microscope lens

You will need:

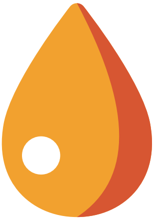
- Clip-on microscope lens or magnifying glass
- Smartphone or tablet (for microscope lens)
- Water repellent leaf (e.g. savoy cabbage leaf, broccoli, nasturtium or lotus leaf)
- Waterproof fabric
- Other solid objects to look at (a sponge, paper or a t-shirt are good)

What to do

Take your pipette and fill it with water. Put a few droplets of water on your leaf and waterproof fabric. Take a look at the surfaces using your clip-on microscope lens or magnifying glass. The microscope lens can clip on to your smartphone or tablet camera.

What did you notice?

Describe what happened to the water droplet and what the surface looks like?



For more information about the lotus leaf (and other awesome surfaces found in nature) check out our 'Awesome Surfaces' video (20 min) with lotus leaf @ 7min 30s https://youtu.be/Dy2kFuDABjk

For more information about the clip-on lens take a look at the 'Seeing the small" video (~10mins long): https://youtu.be/8Xog_UstOFY

Both the leaf and waterproof fabric have a rough waxy surface. Waxy surfaces do not 'like' water (think about trying to mix water and waxy substances like cooking oil). The rough surface stops the water droplet making contact with the solid surface. Note the silvery layer under the droplet; this is air and it prefers to roll off the surface.

By studying water repellent plants we can learn how to make clothes waterproof.

What you can see through your microscope or magnifying glass? Can you see the weaving threads that make up a t-shirt?

You can take a photo through your lens. Upload and share with others on our Padlet page: https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac
Materials Scavenger Hunt video: https://youtu.be/QoRU0aWEs5s

2 Materials building blocks

What makes up a material?

How does your crystal grow?

Crystals are all around us, from sugar or salt to even more expensive examples like diamonds. Crystals are important because they are used in many everyday products including washing powder, medicines and electronics. The process of forming solid crystals from a solution is known as crystallation.
Time to have a go at making a crystal.

You will need:

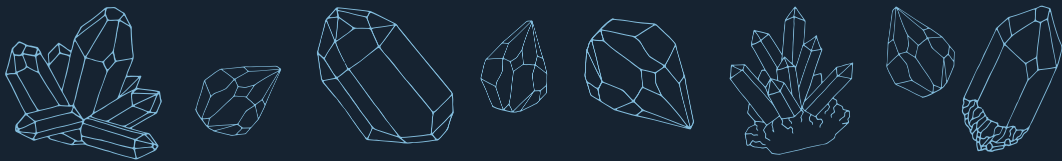
- Pipe cleaner
- String
- Salt
- A clean see through jar
- Hot water

What to do

- Cut the pipe cleaner into 3 pieces and twist together to make a snowflake shape
- Tie one end of the string to the centre of the snowflake and the other end to the pencil - a suitable length to sit in the jar with water.
- Pour hot water into the jar (take care - get an adult to help you)
- Add a small amount of salt and stir. Keep adding salt and stirring until it stops dissolving (you will see it on the bottom of the jar)
- Balance the pencil on the jar so the snowflake is covered but not touching the jar
- Leave overnight

You can take a photo of your crystal before and after crystallisation through your lens. Upload and share with others on our Padlet page:
https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

This activity is taken from Royal Society of Chemistry:
https://edu.rsc.org/resources/outreach-crystal-chemistry/1587article



Changing the shape of crystals

Recrystallisation is used for separating materials that dissolve differently in the same liquid. For example a mixture of salt and soil can be separated by mixing them in water. We can use a sieve to catch the soil that does not dissolve but does allow the water that has salt dissolved to pass through. The salt water solution can then be dried leaving the salt behind. By doing this you can change the shape of the salt crystals - so lets have a go.

You will need:

- Clip-on microscope lens or magnifying glass
- Smartphone or tablet (for microscope lens)
- A shallow dish or watchglass
- Spatula or teaspoon
- Sugar and/or salt
- Tiny amount of boiling water

What to do

- Take your watchglass/shallow dish and put in a small sprinkling of sugar or salt crystals
- Have a look at them using your clip on lens or magnifying glass
- Now add a tiny amount of boiling water to dissolve the crystal (take care – get an adult to help you)
- Wait for the water to evaporate (this is when the water turns into water vapour and leaves the solid behind)

Have a look at the solid that has been left behind – is it the same shape as before?

For more information about the clip-on lens please have a look at our 'Seeing the small' video (~10mins long): https://youtu.be/8Xog_UstOFY

You can take a photo of your crystal before and after recrystallisation through your lens. Upload and share with others on our Padlet page: https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

Inside the crystal

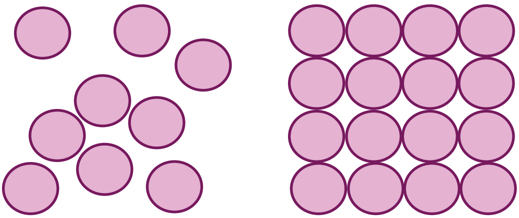
Atoms are the building blocks which make up all materials. They are like Lego bricks of the materials world and together make up bigger building blocks known as molecules.

When atoms pack together they can either be disordered, like a ball pit with balls scattered everywhere or neatly stacked together like tins of beans in the cupboard. Crystals are regions of well-ordered atoms.

ATOMS are the smallest building blocks of all materials and there are 118 of them – these can be found in the Periodic Table (there is one in your box)

MOLECULES are groups of more than one atom that are joined together.

Ions are atoms with a positive or negative charge



You will need:

- Square petri dish or shallow dish
- A 20ml syringe or use a straw
- Bubble mixture- mix washing up liquid in water
- Water

Square petri dish

20ml syringe

What to do

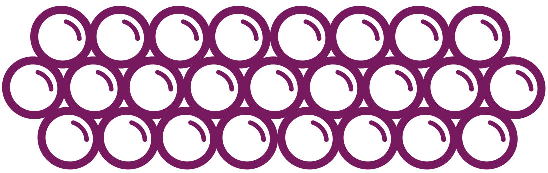
- Take the square petri dish/shallow dish and put in some of the bubble mixture (you can mix the same volume of bubble mixture and water if you like).
- Take the 20ml syringe and pull the plunger up (to fill it with air) and gently place the open end of the syringe into the bubble mixture. Gently push the plunger down to get a stream of air to make bubbles that are roughly the same size (this is difficult to do) or gently blow through the straw. Try and make a small island of bubbles.
- Make two or more islands of bubbles.

What do you notice?

Periodic table: https://edu.rsc.org/resources/updated-periodic-table-printable/1469.article

There are regions of nicely ordered bubbles which is how atoms pack within crystals. Metals are made up of crystals where each crystalline area is called a 'grain'. Sometimes these grains are very large and can be seen without the need of a microscope, look at the galvanised steel over here.

It is difficult to get nice, uniform bubble rafts but have a go.



For more information about making bubble rafts have a look at our video: https://youtu.be/eQWIs-8wdQg

You can take a photo of your bubble rafts to upload and share with others on our Padlet page: https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

3 Bubbling away

We have learned that bubbles can be used to model atoms and show regions of very regular packing, like crystals. But, what are bubbles?
Let's find out ....

Getting gassy with it!!

A chemical reaction occurs when two or more chemicals mix, changing into different chemical compounds. That fizzing reaction happens when citric acid and sodium bicarbonate mix. When they do, they give off a gas called carbon dioxide, or CO_2. They do not mix until they get wet because they need to be dissolved in the water to react.

You will need:

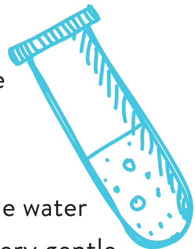
- Citric acid*
- Sodium bicarbonate*
- Centrifuge Tube or two drinking glasses
- Water
- Spatula or teaspoon

*Available in the home baking section at most supermarkets


Centrifuge Tube


Spatula

What to do



- Take a spoonful of sodium bicarbonate and add it to the centrifuge tube
- Take half a spoonful of citric acid and add it to the centrifuge tube
- Mix them together while they are dry
- In another container add a couple of drops of washing up liquid to a little water and gently swirl it. You don't want to make any bubbles just yet, so be very gentle.
- Add a little of your liquid to the tube with your powders in it, and using your scientific observation skills, note down what happens.

You can now make carbon dioxide gas, but what could you use it for?

Well, making carbon dioxide gas in this way is really useful in baking. Sodium bicarbonate is the main chemical in baking powder, something that reacts with the acid in your cake mix to make it bubbly. Those bubbles then get baked into place when the cake proves and rises in the oven.

Extra little experiment - what is the difference between citric acid and sodium bicarbonate?

- You can make a pH indicator from red cabbage to use to tell the difference between acids and alkalis. Red Cabbage pH indicator resource: https://edu.rsc.org/experiments/making-a-ph-indicator-using-red-cabbage/422.article
- In a small beaker or drinking glass mix a little citric acid in water and mix a little sodium bicarbonate in water in another small beaker or drinking glass.
- You can add drops of the cabbage solution to each small beaker or drinking glass.

What do you notice?

The colour changes tell you which liquids are acid (turns red - orange) or alkali (turns blue / purple).

Why not test what is acid and alkali around your home (try soap in water and vinegar)

You can take a photo of your chemical reactions and upload to share with others on our Padlet page: https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

A Different Kind of Bubble Machine

Chemical Engineering is taking the great ideas from chemistry, applying some physics, maths and some engineering design to make them work in the real world. A chemical engineer is able to design a process that makes something work well when it is also scaled up, or made bigger. This activity sees you applying what you know about chemistry to build a small device with only a handful of everyday bits and pieces, to generate bubbles of hydrogen gas. There is a video of this that you can follow on the website.

9 Volt Battery

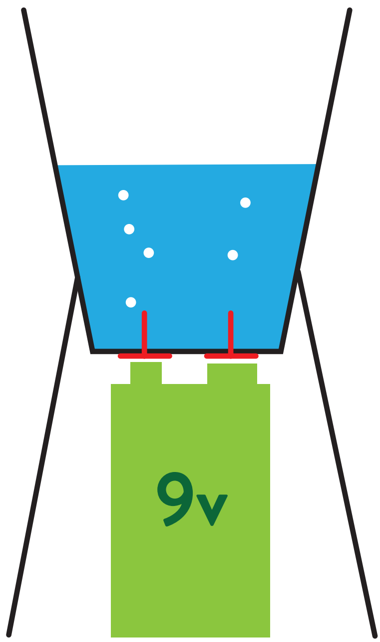
You will need:

- A disposable plastic cup
- 2 drawing pins (careful these are sharp)
- 9 volt battery
- Sodium bicarbonate (available in supermarket)
- Water

Hints and Tips

'What is water made of?'

Chemically, a water molecule is H_2O;
Two hydrogen (H^+) atoms and one oxygen (O^-) atom bonded together. Because of the different charges these atoms have, water is called a polar molecule. Our battery also has a positive (+) and negative (-) terminal, just like each of our atoms in the water molecule. When we use our battery as a power supply we can pull the water molecules apart. We call this process 'electrolysis'. So we need to get the power into the water in a controllable way.



So I just need to get the power into the water, right? Stop! Don't do what you're thinking of doing!

Sure, it's easy to drop the battery straight in, but we can't exactly switch it on and off without putting our hands in the solution, something no scientist should be doing, and it's not great for the battery either.

We need to think like an engineer and find a better way of doing it..................

Think about which materials you have been given that will conduct electricity from the battery. Maybe the metal pins are best for conducting electricity?

'But surely poking pins into a cup will cause it to leak?' This depends on the quality of the material the cup is made of when it is pierced. If it is 'low quality' or brittle, then it may crack and leak. If so, you may need to use a drop of glue to seal the pins into place. Be careful though... is glue the sort of material that conducts electricity if you get it on the surface of the pin that touches the battery? A softer cup should fit closely around the hole you've made with the pin.

Why is nothing happening?

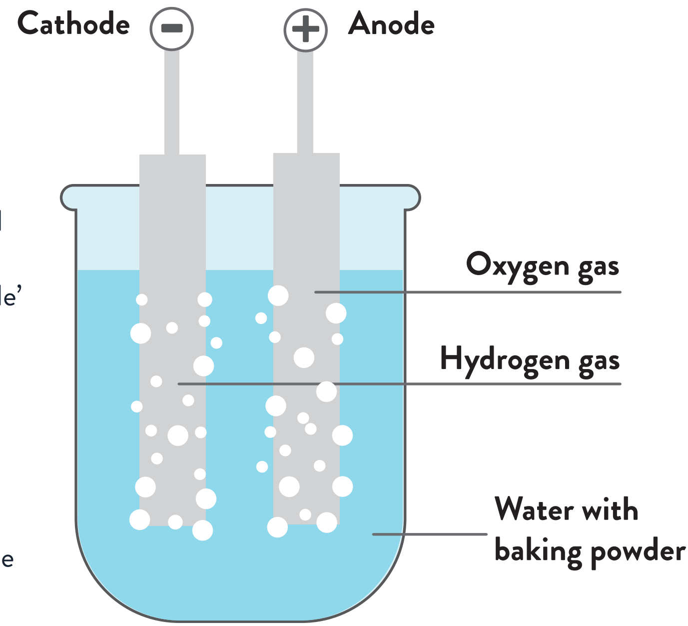
Pure water has an electrical conductivity about one millionth that of seawater, so the electrolysis of pure water occurs very slowly or not at all. If a water-soluble electrolyte is added, the conductivity of the water rises considerably. The electrolyte dissociates into cations and anions. Try dissolving about a quarter of a teaspoon of the bicarbonate of soda in your cup and standing it on the battery again.

WOW Yes, and now it's time to observe like a scientist.
Watch it carefully, writing down all the things you are seeing.

Do the pins make the same amount of bubbles? If not, which end of the battery produces the most? If you run your experiment for ten minutes, what happens to the pins and the solution?

Which gas is which?

Remember that water is H_2O, so a water molecule is made of two hydrogen atoms to every oxygen atom, so you will get that ratio of gas created from the pins. Twice as much hydrogen is produced to oxygen. Consider which elements of the 'polar molecule' are positive and negative. To which electrode will they be attracted? The H^+ hydrogen ions are attracted to the free electrons provided at the negative (-) terminal of the battery. The positive end of the battery is happy to collect the extra negative electrons from the O- oxygen atoms.



Why has the water changed colour?

Great question! Did you notice the pin attached to the positive terminal of the battery was turning dark? This pin had a good stream of oxygen bubbles coming from it. What material do you think the pin was made of? It was likely steel, which contains a lot of iron. What happens to iron when it gets wet and can bond to a lot of oxygen? Yes, it starts to corrode and forms iron oxide, or rust. We call this a secondary reaction, and is really important when we think about the materials we use to make our reaction vessels in engineering.

FACT: We make only 5% of the world's hydrogen this way, which gets made as a by-product of producing chlorine gas by using electrolysis to split seawater. However, electrolysis is used to create oxygen on the International Space Station. What problems would you think may change your design? Zero gravity perhaps?

Balancing the bubbles

The electrolysis experiment you have just carried out is a good way to learn something about how we balance chemical reactions. The clue is in the amount of bubbles you got from each pin, and it begins with the water molecule, H_2O. When we write the breaking apart of the water molecule it looks like this:

$$H_2O \longrightarrow H_2 + O$$

That looks alright, but there is something not quite right with it. Hydrogen, as a gas, is a diatomic molecule; two hydrogens bonded together. That means the H_2 part is correct. However, oxygen is also a diatomic molecule when it is a gas so that should be O_2, not just O, or one atom.

$$H_2O \longrightarrow H_2 + O_2$$

Now that is fixed, the equation looks worse. The rules of chemistry mean that what we put in, must also come out. Yet here, we've gained an oxygen atom to make a diatomic oxygen molecule, O_2. When we break apart one water molecule, we get just one oxygen atom, so we need to break apart another water molecule to get another oxygen. How does this change our balance of the chemical reaction?

$$2H_2O \longrightarrow H_2 + O_2$$

This now looks a little better when we compare both sides of the equation. We've now got the right amount of oxygen atoms in the two water molecules to give us the diatomic oxygen (O_2) molecule. But breaking apart the second water molecule has what effect on the amount of hydrogen we have? Can you write the correct equation so that the hydrogen gas is properly balanced.

Hopefully you realised that you can use the same trick of adding a 2 in front of the hydrogen molecule in the second half of the equation. $2H_2O \longrightarrow 2H_2 + O_2$ When you count all the atoms on both sides of the equation, you will see they match up; four hydrogen atoms and two oxygen atoms.

Well done, you've balanced your first chemical reaction.

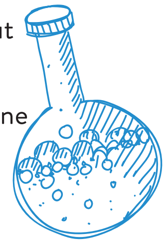
Making bubbles last longer

We have looked at two ways of making gas bubbles but did you notice that they disappear quickly? There is a way to stabilise bubbles (and make them last longer) so let's do an experiment.

You will need:

- Two flat-bottomed centrifuge tubes or two small drinking glasses
- Two pipettes or 5ml medicine spoon or syringe
- A fizzy tablet (fizzy vitamin c tablets)
- Bubble stuff
- Water

What to do



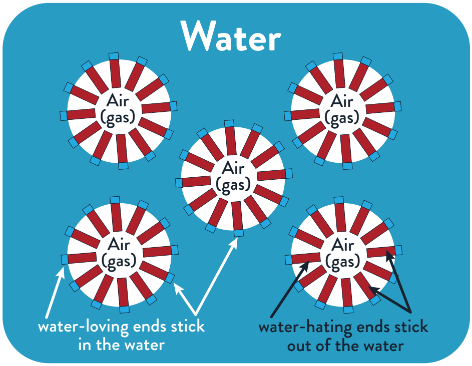
- Take two flat bottomed centrifuge tubes/two small drinking glasses and put 5ml of water in each tube.
- Add about 1ml of bubble mixture (you can also use washing up liquid) to one of the tubes.
- Take your fizzy tablet and break it into at least two pieces and put a piece of tablet in each tube.

What do you notice?

How the bubble mixture works....

Bubble mixture (and washing up liquid) are made up of a pretty cool type of chemicals called **surfactants**. Surfactants both love and hate water which is why they are used in soap to wash your hands. The water-hating bit loves the oily dirt on your hands. The water-loving bit sticks to the water and so helps remove the dirt from your hands.

A soap bubble is a ball of gas that is wrapped up in a very thin layer of surfactant solution (water with surfactants in it). These surfactants line up where the water and gas meet with their water-loving end sticking in the water and their water-hating end sticking into the gas. This helps to stabilise the thin liquid film that surrounds the gas and makes the bubbles last longer. Surfactant molecules also make the water easier to stretch which helps it to capture the air bubbles.



So what we need to make bubbles and foams are....?

You could have a go at making elephant toothpaste with the video: https://www.youtube.com/watch?v=VqNL-3HcRsE

Now we know how to make bubbles and gas, let's have some more fun...

Fizzy Rockets

Video Link: https://youtu.be/UobhqGu0eMU

Gas takes up a lot more space than solids and liquids, so in a closed container the generation of gas in a chemical reaction can cause it to explode as it cannot contain the gas. We have learned that when sodium bicarbonate is mixed with citric acid it makes carbon dioxide (a gas).

We can use this knowledge to produce carbon dioxide in a closed film canister which makes the lids pop off when the pressure inside gets too high and this launches your rocket!

You will need:

- Photo film canisters or any plastic tube with a pop on lid
- Stickers and coloured sharpie pens (for decoration)
- Spatula
- Citric acid
- Bicarbonate of soda
- 5ml pipette
- 100ml plastic beaker
- Water

What to do

This experiment will mean surfaces getting wet so ideally do it outside or somewhere inside where it is easy to clean up afterwards and it doesn't matter if things get hit by flying film canisters.

IT IS IMPORTANT THAT YOU HAVE READ THE HEALTH AND SAFETY SECTION BEFORE CARRYING OUT THE ACTIVITY – THE ROYAL SOCIETY OF CHEMISTRY, FRIENDS OF COTTERIDGE PARK AND THE DEVELOPER DO NOT ACCEPT ANY LIABILITY

1) Take a film canister (if you are old enough, you may reminisce!) and decorate it by drawing on it with Sharpie pens or decorating it with the star stickers and any other stickers, tape or glitter glue that you may have around the house. You can share photos of your rocket (ask an adult) and post on the Padlet Page - https://padlet.com/DiscoverMaterialsGroup/37xw8q8czs00nfac

2) Mix half a spatula of citric acid and a full spatula of sodium bicarbonate in a 100ml beaker – you can experiment with different ratios

3) Place a teaspoonful of this mixture into the film canister

4) Add about 3ml of water to the mixture and put the lid on the canister

5) Quickly place the sealed canister upside down on a flat, firm surface and stand back (the rocket is now primed)

6) Count down and wait for the rocket to take off.

Things to investigate

- Try changing the citric acid to sodium bicarbonate ratio to see which makes the rocket fly highest.
- Try making a bigger rocket using a bigger bottle (you may need to add sticks to stabilise it).
- Try acetic acid (vinegar) rather than citric acid.
- Perhaps try out the different ratios in cups (or even the flat-bottomed centrifuge tubes with the lid off) and add water to see which one fizzes the most. Then use your fizziest mixture in your rocket.

Safety Checklist:

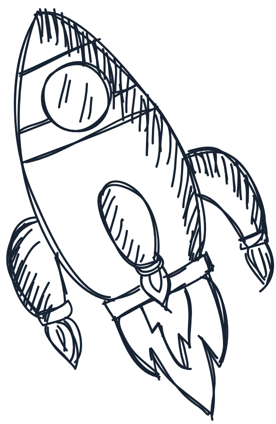
Be careful with:

1) Eye damage (from a flying rocket)
   -Do not stare directly down on a primed rocket
2) Electrocution
   -Do not carry out this experiment near electrical devices

☐ I am wearing my eye protection

☐ I have read the safety notes

Remember to use your common sense



You can use the same reaction to make a bubble boat:
https://edu.rsc.org/resources/a-chemically-powered-boat-a-bubble-race/615.article

How to Make an Epic Bath Bomb

When you think of things that fizz, the bath bomb has to be up there. The main chemicals are the ones you have just used; sodium bicarbonate and citric acid. They combine in your bath water to create carbon dioxide, the gas that makes a bath bomb fizz. Obviously adding too much water will cause the chemicals to react, so we need to add something else instead of water.

You will need:

- Citric acid
- Sodium bicarbonate
- Epsom salts
- Two small paper sauce pots
- Teaspoon
- a little oil you can find in your kitchen such as vegetable oil, olive oil, sweet almond oil or even any essential oils if you have some.

What to do

In one of the sauce pots, mix your dry ingredients
2 spoons of sodium bicarbonate
1 spoon of citric acid
1 spoon of Epsom salts

In a separate container mix your wet ingredients. (You really won't need much but you can decide)
3 parts of sweet almond oil, olive oil, or essential oil
1 part water

Now the trick is to add some of your liquid in, a drop at a time, then mix it in before it has a chance to react and fizz.

- When it feels slightly damp press it carefully into the sauce pot.
- Leave it to dry overnight, when you can pop it out of its paper pot.
- To use your bath bomb, drop it in a bowl of water and you can watch it fizz.

Observe and note what happens.

You should be able to smell the oil that you used to bind it together.

Does the water feel different?

That would be the magnesium sulphate or Epsom salts that are often used by chemical engineers as a water softener.

Think about what you could add to your bath bombs to make them more interesting?

Maybe different shapes, colours, or scents. Do they have to be all the same colour? How would you make a striped bath bomb?

4 What next?

Science is about discovering the world around you by asking questions and then doing experiments to try to answer these questions (and often experiments can lead to more questions!).

To plan an experiment you need to think about the following:

What do I want to know?
What experiment can I do to find out the answer?
What equipment do I need?
What can go wrong with the experiment and can it hurt me or others (this is called a 'Risk Assessment' and is a very important safety checklist)
What did I find out?

You also need to write down your experiment plan and the results in a lab book. You can find your own lab book in the box and now you have your own science kit why not have a go at asking your own questions and carrying out your own experiments.

You will need:

- Notebook
- Pen and Pencil
- Your own science question (discuss with an adult)
- Equipment needed for your experiment

To learn more about materials science visit our website:

www.discovermaterials.uk

Congratulations!

You have completed your CoCoMicro Book

ROYAL SOCIETY OF CHEMISTRY

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