STEM Program

Campfire Chemistry

What's a camp without a good campfire? A campfire is a chemical reaction called combustion. To make a campfire, you need oxygen, heat, and fuel. We have two experiments for you to try. In the first experiment we will add some easy-to-source household chemicals to change the colour of the flames. If you're up for a bit more of a challenge, you can then learn more about how the fire triangle works.

WARNING: Never breathe the resulting smoke or cook on a fire after adding any chemicals. If you wouldn't eat it, then don't cook on it!

Experiment 1

Colourful flames

Flames are not always yellow. Different colours can be made by adding different chemicals to a fire. The colour can also depend on how hot the flame is burning, which relates to what fuel is being burnt. All in all, the colour of a flame can tell us a lot of information!

Plan

What you will need

- A fire: The coloured fire experiments can be done using an actual campfire, a cast iron camp stove or a ceramic bowl placed on a heat-proof surface and filled with methylated spirits to about 1cm from the bottom, or even a tea candle.
- Heat-proof gloves
- Fire blanket and fire extinguisher
- Metal teaspoons (make sure they are clean between each chemical you add)
- Spray bottle (optional) with mist function, the small atomiser travel type ones work well. You will need one bottle per chemical.
- The household chemicals listed in the table on the next page. Each experiment/demo will use about a teaspoon, if you are adding it directly to the fire.

Do

Method

1. Whilst this experiment can be done at any time of the day, it works best when the room is a little darker, or outside after the sun has set.
2. Light the fire, and with gloves on, carefully sprinkle about a teaspoon of one of the chemicals into the flame. Watch the flame change colour!
3. Try each of the other chemicals in the same way.
4. Another way to introduce the chemicals is to make a saturated solution of the chemicals and put them into your spray bottles. Spraying these solutions into the flame can make for flashier colours. To make a solution, put some water into the bottle, add a spoonful of the chemical powder to the bottle and shake well. If the powder dissolves completely, add some more powder and repeat until the powder doesn't dissolve anymore. It doesn't matter if there is some powder sitting at the bottom of the bottle. You need a separate bottle for each chemical.
5. A final alternative is to soak some wood in the chemical solutions (make the saturated solutions the same way as above). Make sure you soak each piece of wood in only one chemical. The wood needs to be completely dry before you use it, so make it well in advance or oven dry it. When you have your campfire just add the sticks to a hot fire to see the colours. This is a safer option for Joeys and Cubs.

Review

Test some variables

Try some of the different techniques suggested and compare which gives the most obvious flame colour. Does changing the temperature or type of flame change your results?

Household Chemicals

Sodium Chloride	Table salt. This is an edible food stuff, with negligible risk.	**Orange Flames** 
Potassium sulfate	Fertiliser available in hardware stores and nurseries; also called sulphate of potash. Make sure you read the safety guidelines on the back of the packet, wear safety gloves and goggles.	**Purple Flames** 
Potassium chloride	Salt substitute for example Diet Rite Lite Salt from supermarket. This is an edible food stuff, with negligible risk. Wash hands after use.	**Purple Flames** 
Copper sulfate or copper chelate	A specialised fertiliser, called copper sulfate; or copper lignosulfonate available in hardware stores and nurseries; also called copper chelate). For example Manutec 500g Copper Sulphate Soluble available from Bunnings. Make sure you read the safety guidelines on the back of the packet, wear safety gloves and goggles.	**Blue Flames** 
Magnesium sulfate	Commonly called Epsom Salts, available in supermarkets. This material is used in bath salts to ease achy muscles. Wear safety gloves and goggles, and wash hands after use.	**White Flames** 
Flour	Flour tossed carefully into the fire. This is about increasing surface area to volume, causing quick combustion, which explains how it flares up when thrown into a fire. Remember to wear clothing made of natural fibres, for example cotton, not your Scout uniform which is made of synthetic materials.	**Flare Ups** 
Sugar	Throw in some sugar into the fire. This adds additional fuel to the fire. Remember to wear clothing made of natural fibres, for example cotton, not your Scout uniform which is made of synthetic materials.	**Creates Sparks** 
Borax (sodium tetraborate) **You MUST follow all safety instructions carefully.**	Available in supermarkets. As per Safety Data Sheet: https://bit.ly/3A4NVji P201 Obtain special instructions before use. P271 Use only outdoors or in a well-ventilated area. P280 Wear protective gloves/protective clothing/eye protection/face protection/hearing protection. P261 Avoid breathing dust/fumes. The more serious effects outlined in the SDS are long-term effects, which are not likely to occur from running the activity once.	**Green Flames** 

Safety Tips

- Make sure you have an adult handy to supervise this experiment. Keep the fire blanket and extinguisher close in case of emergencies.
- For safety wear cotton clothing, where possible, and remove your scarves so they don't drop in the flame. Make sure your hair is tied back.
- Wear safety goggles and gloves, especially when handling Borax.
- Make sure the area you are using is well ventilated, outdoors works well!
- Never cook on a fire after you have added any chemicals.
- If you are using the spray bottle option, ALWAYS SPRAY AWAY FROM OBSERVERS.
- If you are using a bowl of methylated spirits for your fire, the safest way to put the fire out is to simply wait for all of the fuel to be used up. If you need to put it out quickly, place a ceramic plate upside down on top of the bowl, completely covering it. This will stop oxygen getting to the flame and put the fire out in a few seconds.
- Make sure you wash your hands thoroughly before and after handling the chemicals.

Why Does This Happen?

As the fire burns, atoms from the chemicals we add receive heaps of heat energy. Much like us running around being active when we feel the need to work off excess energy, these atoms then emit light energy. Atoms from different elements produce different wavelengths of light. Our eyes see the flames as different colours depending on what wavelengths of light the excited atoms emit.

A common chemical analytical technique called the 'flame test' takes advantage of this phenomenon, and can be used to detect the presence of certain elements (usually metal ions) in chemical compounds. While this test can only tell us whether a type of atom is present or not, a more advanced version (Flame Emission Spectrophotometry) is even able to let us know how much of it is present!

Resources

How to Make Colored Fire at Home (sciencenotes.org)

Experiment 2

Make your own Fire Extinguisher

A campfire needs three ingredients.

1. Fuel: A candle,
2. Oxygen: everywhere; and
3. Heat: A match should do the trick.

These are called the “fire triangle”. In this experiment you will make your own fire extinguisher!

Plan

What you will need

- Baking soda (sodium hydrogen carbonate, also called sodium bicarbonate, bicarb soda, available in supermarkets)
- Vinegar
- 1 tablespoon
- A large glass or jar
- Some tea light candles
- Aluminium foil to make a base for the candle

Do

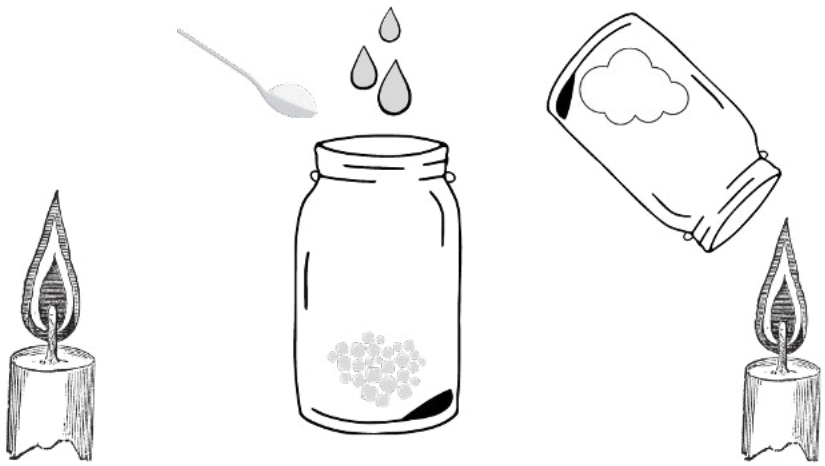
Method

1. Light the candle. Make sure you have the help of an adult if you are a smaller human.
2. Mix some baking soda and vinegar in the jar to make a frothy mixture.
3. Tip the jar over the candle, making sure only the gas from the chemical reaction between the baking soda and vinegar comes out. Do not tip the liquid out.
4. Watch what happens to the candle.
5. Re-light the candle. Either use a new jar or show that there is no more of the invisible gas by inverting the glass above the candle (the candle should remain lit). Slowly lower the glass until the lip of the glass is below the flame. What happens? Is this what you expected?

Review

Test some variables

What are some other techniques you could use to remove one of the three fire triangle ingredients and extinguish the fire?



Safety Tips

- The “fire triangle” experiment is best done using some tea candles.
- Make sure you have an adult handy to supervise this experiment.
- For safety wear cotton clothing, where possible, and remove your scarves so they don’t drop in the flame. Make sure your hair is tied back.
- Inverting the cup over the candle is sufficient to extinguish the flame.
- Keep the fire blanket close in case of emergencies.
- To protect the table top from any wax, make a wide “base” and holder for the candle using aluminium foil.
- Some of the experiments can be messy. It is suggested that an old cloth or towel be used to cover the table. When using small candles, a thick cloth or towel can also be used as a make-shift fire blanket.

Why Does This Happen?

Fire is an oxidation reaction, and so needs oxygen. The oxygen bonds with the carbon in the wood to form carbon dioxide, and releases heat and water along the way.

Careful observation of the flame will show that solid and liquid wax does not burn. The purpose of the heat and wick is to enable the wax to evaporate; it is the wax vapour that mixes with the oxygen in order to burn.

The reaction of baking soda and vinegar produces carbon dioxide gas (which is what causes the bubbles). This carbon dioxide gas is invisible and is more dense than air, which is why it can be collected and poured like an invisible liquid. The carbon dioxide can extinguish flames because it prevents oxygen reaching the fuel.

The flame also produces carbon dioxide gas (and other things like water vapour). The heated carbon dioxide gas rises because it is less dense than cool air, which is why carbon dioxide can be collected in an upside-down cup held over the flame and then can extinguish the flame.

Resources

Experiment 16: Fire Extinguisher - Dyson Foundation - Challenge Cards

Go Science Girls: Candle Under Glass Experiment

Science of Outdoors

The Science of Outdoors is a National Science Week project, undertaken in collaboration with Fizzics Education. These instructions and supporting videos were prepared by Scouts for Scouts.

Scouting has always been strong on STEM skills. Maths to calculate catering quantities and navigate, the science of water purification, the physics of abseiling, and the engineering of pioneering structures – they all have their place. In the current program for our youth members, STEM and Innovation forms one of six Special Interest Areas that enable Scouts to set goals and pursue their own ideas.

SciScouts OUTDOORS

Fizzics Education

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