Flame colours – a demonstration

This demonstration experiment can be used to show the flame colours given by alkali metal, alkaline earth metal, and other metal salts. This is a spectacular version of the ‘flame tests’ experiment that can be used with chemists and non-chemists alike.

It can be extended as an introduction to atomic spectra for post-16 students.

Lesson organisation

This experiment must be done as a demonstration. It takes about ten minutes if all is prepared in advance.

Preparation includes making up the spray bottles and conducting a risk assessment.

Your employer’s risk assessment must be customised by determining where to spray the flame to guarantee the audience’s safety. Use a fume cupboard unless you are sure of an alternative space.

Apparatus and chemicals

Eye protection
Access to fume cupboard (unless a safe alternative space is available)
Trigger pump operated spray bottles (see note 1)
Bunsen burner
Heat resistant mat(s)
Hand-held spectroscopes or diffraction gratings (optional)

Samples of the following metal salts (no more than 1 g of each) (see note 2):
Sodium chloride (Low hazard)
Potassium chloride (Low hazard) (see note 3)
Lithium chloride (Harmful) (see note 3)
Copper sulfate (Harmful, Danger to the environment).
Ethanol (Highly flammable), approx 10 cm³ for each metal salt.
or IDA (industrial denatured alcohol) (Highly flammable, Harmful)
Technical notes

Sodium chloride is **Low hazard**. Refer to CLEAPSS® Hazcard 47B.
Potassium chloride is **Low hazard**. Refer to CLEAPSS® Hazcard 47B.
Lithium chloride is **Harmful**. Refer to CLEAPSS® Hazcard 47B.
Copper sulfate is **Harmful, Danger to the environment**. Refer to CLEAPSS® Hazcard 27C.
Ethanol is **Highly flammable**. IDA (industrial denatured alcohol) is **Highly flammable**, **Harmful**. Refer to CLEAPSS® Hazcard 40A.

1 Spray bottles of the type used for products such as window cleaner should be used. These piston-operated spray bottles should be emptied, cleaned thoroughly and finally rinsed with distilled water. Ideally, one bottle is needed for each metal salt. Never use spray bottles with a rubber bulb - the flame may flash back into the container.

2 The chlorides of metals are the best but other salts also work. Make a saturated solution of each salt in about 10 cm³ ethanol. To do this, add the salt to the ethanol in small quantities, with stirring, until no more will dissolve – often only a few mg of salt will be needed. Place each solution in a spray bottle and label the bottle. The solutions can be retained for future use. They can be stored in the plastic bottles for several weeks at least without apparent deterioration of the bottles.

3 Potassium iodide and lithium iodide can be used instead. As a general rule, chlorides are usually suggested as they tend to be more volatile and more readily available. These two are in fact a little more volatile than the chloride, and potassium iodide is certainly likely to be available (refer to CLEAPSS® Hazcard 47B). Other metal salts (e.g. those of calcium and barium) can also be used provided an appropriate risk assessment is carried out. Barium chloride is toxic but gives a different colour (refer to CLEAPSS® Hazcard 10A), while calcium chloride (Irritant) and strontium chloride (Irritant) are different again (refer to CLEAPSS® Hazcard 19A).

4 Care should be taken not to allow excess ethanolic solution to accumulate on the heat resistant mats. There is a risk of this igniting with the proximity of the Bunsen burner flame.

Procedure

**HEALTH & SAFETY:** Carry out the whole experiment in a fume cupboard or an area you have previously shown to be safe. Wear eye protection. Ensure that the spray can be safely directed away from yourself and the audience.

a Darken the room if possible.

b Light the Bunsen and adjust it to give a non-luminous, roaring flame (air hole open).

c Conduct a preliminary spray in a safe direction away from the Bunsen flame. Adjust the nozzles of the spray bottles to give a fine mist.

d Choose one spray bottle. Spray the solution into the flame **in the direction you have rehearsed**. Repeat with the other bottles.

e A spectacular coloured flame or jet should be seen in each case. The colour of the flame depends on the metal in the salt used.

f As an extension, students can view the flames through hand-held spectrosopes or diffraction gratings in order to see the line spectrum of the element. (Diffraction gratings work better. A better way to produce a steady source of light is to use discharge tubes from the Physics Department – with a suitable risk assessment.)
Teaching notes

The colours that should be seen are:

<table>
<thead>
<tr>
<th>Element</th>
<th>Colour Description</th>
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<tbody>
<tr>
<td>sodium</td>
<td>yellow-orange (typical 'street lamp' yellow)</td>
</tr>
<tr>
<td>potassium</td>
<td>purple-pink, traditionally referred to as 'lilac' (often contaminated with small amounts of sodium)</td>
</tr>
<tr>
<td>lithium</td>
<td>crimson red</td>
</tr>
<tr>
<td>copper</td>
<td>green/blue</td>
</tr>
<tr>
<td>calcium</td>
<td>orange-red (probably the least spectacular)</td>
</tr>
<tr>
<td>barium</td>
<td>apple green</td>
</tr>
<tr>
<td>strontium</td>
<td>crimson</td>
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</tbody>
</table>

The electrons in the metal ions are excited to higher energy levels by the heat. When the electrons fall back to lower energy levels, they emit light of various specific wavelengths (the atomic emission spectrum). Certain bright lines in these spectra cause the characteristic flame colour.

The colour can be used to identify the metal or its compounds (e.g., sodium vapour in a street lamp). The colours of fireworks are, of course, due to the presence of particular metal salts.

Reference

This experiment has been reproduced from Practical Chemistry: http://www.practicalchemistry.org/experiments/intermediate/structure-and-bonding/flame-colours-a-demonstration,102,EX.html

Useful resource


Flame tests gives another slightly different version, involving establishing some flame colours and then using them to identify unknowns: http://www.creative-chemistry.org.uk/activities/flametests.htm