

theme:

leisure & lifestyle

job:

Nina Gronw-Lewis, Glass artist and Jewellery designer

activity outline

As a glass artist, Nina uses all sorts of coloured glass. In this activity, pupils make their own borax glass beads. They then learn how to colour their beads, carrying out flame tests on metal compounds.

You will need one lesson.

It is suggested that pupils work individually or in pairs. A teacher demonstration of a flame test might be advisable before pupils do it themselves.

The pupil sheet provides an introduction, step-by-step instructions, a results table to complete and some questions to help pupils compare results.

Teacher notes overview

- 1 Curriculum links:** where this activity can fit with the 2008 KS3 Programme of Study and Scottish 5-14 Science Curriculum.
- 2 The Video:** providing a synopsis of the video content and ideas for viewing.
- 3 The Practical:** including *Equipment lists*, *Health and safety notes*, a *Possible approach* (a comprehensive, suggested way of planning the lessons) and an *Underlying science* section (providing detailed information about the various scientific principles involved).
- 4 Possible extensions:** suggestions for other practical activities using the video, or extending the suggested activity.
- 5 Associated jobs:** guidance on how to deliver a plenary activity (or, if you wish, a stand-alone activity) focusing on the video interviewee, including a photo of the interviewee to place at the centre of a spider diagram.

curriculum links

This lesson can be used to help teach part of the 2008 Key Stage 3 Programme of Study (England and Wales):

Range and Content:
3.2c

Attainment Targets:
AT1, AT3

Key Concepts:
1.1a, 1.1b, 1.2a

Key Processes:
2.1a, 2.1b, 2.1c, 2.2a, 2.3

Curriculum Opportunities:
4a, c, k

This lesson can be used to help teach part of the Scottish 5-14 Science Curriculum:

Main curricular links

E&S3 Changing materials

Attainment Targets

Knowledge & understanding:

Level B

- Describe how everyday materials can be changed by heating and cooling

Level F

- Distinguish between chemical and physical processes

Investigating skills:

Level C

- ... make appropriate observations

Level D

- draw conclusions consistent with the results



the video

Synopsis of the video

Among other things, Nina makes these interesting points:

- Nina has to use pieces of glass with the same “coefficient of expansion” or they will not fuse correctly.
- Glass kilns and ceramic kilns are different, because of the way they heat up and cool down, and the temperatures they operate at.
- Nina didn’t realise that science would be needed in art, but now she uses science and maths every day.
- Nina uses maths to help run her business.

Watching the video

There are a number of things you might do before showing the video to your class.

- 1** Preview the video and write a few quick-fire questions. Then you can tell your class that they will be tested on their observation when it’s finished. This is an excellent way of encouraging them to pay attention!
- 2** Ask pupils to watch the video through once. Then ask them to generate one question that could be answered from the video and one question they would like it to ask but the video did not answer. These questions are then exchanged with another pupil and the video is watched a second time. This gives pupils an opportunity to focus on something they may have missed first time, and provides a basis for discussion on what was learnt from the video and what additional information is needed.
- 3** Ask pupils what sort of person might become a Glass Artist. Does anyone in the class think they’d like to be a Glass Artist or make jewellery? When the video has been watched, ask the questions again. Has anyone changed their mind/opinions?
- 4** Ask pupils to spot the science in the clip.



the practical

Equipment

(per pupil/pair)

- 4 x nichrome wires (about 10 cm)
- watch glass
- Bunsen burner and heat-resistant mat
- powdered borax (hydrated disodium tetraborate)
- access to labelled watch glasses containing small amounts of various finely powdered transition metal compounds, such as:
 - ▶ copper(II) oxide and/or copper(II) sulfate (both **harmful**)
 - ▶ iron(II) oxide and/or iron(II) sulfate (**harmful**)
 - ▶ iron(III) oxide and/or iron(III) sulfate (**irritant**)
 - ▶ manganese(II) sulfate and/or manganese(IV) oxide (both **harmful**)
 - ▶ chromium(III) potassium sulfate (chrome alum) (**irritant**)
 - ▶ cobalt(II) chloride and/or cobalt(II) nitrate (both **toxic** and **sensitisers**)
 - ▶ nickel(II) sulfate and/or nickel(II) nitrate (both **harmful** and **sensitisers**)

Health and safety

- Most of the metal compounds are classified as **harmful** or **irritant**. Only tiny quantities are needed – a quarter spatula is ample for many pupils to share. They should be pre-dispensed into labelled watch glasses – one for each compound.
- Cobalt and nickel salts are sensitisers by skin contact or inhalation and cobalt is carcinogenic by inhalation, so may be inappropriate for use with some classes. Instead, they could be used to demonstrate the technique beforehand.
- Pupils with heat-sensitive fingers could push the wire into a cork to use as a handle.
- Eye protection must be worn.
- Hot glass beads should be held over the heat-resistant mat at all times, in case the molten glass drips.

Possible approach

The video shows Nina Gronw-Lewis, a Glass Artist. She uses various types and colours of glass to make, among other things, stained glass sculptures and jewellery.

Discuss the uses of glass, and the properties required. Pupils will probably suggest that for windows it must be transparent and colourless. Examine a sheet edge-on. (Grind or fire-polish sharp edges.) Explain that the pale green colour is due to impurities – traces of iron in the sand it was made from. (Sand is slightly brown, due to iron oxide.)

Coloured glass, like that used by Nina, is made by adding small amounts of various transition metal compounds to molten glass.

Pupils investigate how the colour depends on the metal compound used, and on the heating conditions. It may be advisable to demonstrate the technique before they start.

Explain that they will use borax glass, since the melting point of normal (silica) glass is too high.

Pupils may work individually or in pairs. Each pupil or pair needs borax, but the metal compounds should be distributed around the class. They can then be swapped between neighbours. The pupil worksheet specifies making four beads, using two metal compounds, each under oxidising and reducing conditions.

If time is short, a pair can work concurrently, one using the oxidising flame, and the other the reducing flame.

Other pupils' results, using different compounds, should then be added to the table. If a wider variety is used, the teacher can draw up an appropriately enlarged table.

Encourage pupils to discuss their results and try to draw conclusions about the effects of different compounds. They should find that:

- it is the metal, rather than which compound of the metal, that determines the colour;
- beads made with the same metal have the same colour (e.g. blue), but the shade or depth of colour varies – it depends how much compound was picked up on the bead;
- the colour of the bead sometimes matches the colour of the metal salt used, but not necessarily – and not if a metal oxide was used;
- beads heated in the inner and outer flames often differ in colour.

Other pupils' results, using different compounds, should then be added to the table. If a wider variety is used, the teacher can draw up an appropriately enlarged table.

Underlying science: Basic principles

Borax glass

- On heating, borax (hydrated disodium tetraborate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) swells up losing water and melts to form a colourless glass.
- The glass is similar to *normal* glass, but contains boron instead of silicon. (It contains sodium ions in an amorphous lattice of boron and oxygen atoms.)
- Pyrex® and laboratory glassware are made from borosilicate glass, which contains both boron and silicon in the lattice.

Colours

- Colour is a general characteristic of transition metal compounds.
- Transition metal compounds react with the borax glass to form coloured borates, such as $\text{Cu}(\text{BO}_2)_2$.
- The colour of the metal borate depends on the metal, its concentration and its oxidation state. So:
 - ▶ borax beads made using different compounds of the same metal have the same colour;
 - ▶ only tiny concentrations are needed to impart colour – too much makes the colour much deeper, and the glass less transparent;
 - ▶ holding the bead in the outer (oxidising) and inner (reducing) areas of the flame gives the metal different oxidation states – and thus different colours.
- The colour may also differ between hot and cold glass.
- The colours have been used for analytical purposes. The *borax bead test* was one way of identifying the cation in a transition metal compound.

The Bunsen flame

- The outer part of the flame contains more oxygen (from the surrounding air) and less gas (most having already burned in the inner section). The flame is oxidising – it produces a higher oxidation state of the transition metal ion, e.g. Fe^{3+} .
- Conversely, the inner part contains relatively more gas and less oxygen. The flame is reducing, producing a lower oxidation state, e.g. Fe^{2+} .

Further information on glass colouring

<http://1st.glassman.com/articles/glasscolouring.html>

possible extensions

1 Why does position in the flame make a difference?

With brighter pupils, challenge them to think scientifically and suggest reasons **why** the inner and outer flames produce different results. (Initially do not mention oxidising/reducing conditions.) The most likely response is difference in temperature. With a bit of prompting, they should appreciate that the different colours in the flame show that different chemical reactions are occurring, and that this is due to differences in the proportions of air and gas (methane). The differences affect the reaction of the transition metal compound with the glass. See *Underlying Science* above.

2 What about red glass?

Pupils may notice that they have not made any red beads. Challenge them to find out the metal(s) in red glass – and thus why it is more expensive than most blues or greens. [Answer: gold. Copper can also be used, but the process is difficult.]

3 Why do things appear coloured?

A chance to introduce, or recall, the spectrum and the reflection, absorption and transmission of light. (KS3, Unit 8K, Section 10)

4 Heating glass

Challenge pupils to look up the melting point of glass. They won't find it – only 'softening point' of various types of glass – because glass is not a single compound. All types of glass are mixtures, and gradually become softer over a range of temperature. This is easily demonstrated with a glass rod. It enables glass to be bent, moulded, blown and joined (fused together).

Nina glues pieces together, then heats them just enough to fuse permanently without softening enough to change shape.

Pupils should know about expansion/contraction. Discuss the problems of this with glass, and why we use borosilicate glass such as Pyrex®. Nina uses glasses with similar *coefficients of expansion* – they expand by about the same proportion. Ask pupils what would happen if the glasses differed too much.



associated jobs

A STEM (Science, Technology, Engineering and Maths) education provides pupils with skills and knowledge that are useful in all sorts of careers. The video demonstrates how Nina, a Glass Artist, uses such skills on a daily basis.

Nina works with numerous people – some directly, some indirectly. Some use STEM skills, others don't. By exploring this network of associated jobs, pupils will, hopefully, begin to see that even those in non-STEM jobs will find STEM skills useful – if they're communicating with someone "in-STEM", for example, some knowledge of their work will be a great help.

Nina's spider diagram

Try placing Nina at the centre of a spider diagram (we've provided a photo of Nina which you could use – overleaf). You could either create worksheets for pupils to complete themselves, or create the diagram on your whiteboard and then pool ideas.

Ask pupils: "who does Nina work with". They may draw information from the video – we see a brief shot of somebody (a silversmith) sharing her studio, for example – or they may come up with new ideas, such as glass makers, kiln makers or tool suppliers. Other, less obvious, suggestions might include the tax man (Nina has to keep her books up-to-date!) or electricians (Nina has to keep her Kilns working – and they use a lot of electricity).

Now ask pupils which of those jobs are clearly "in-STEM". Who else might find some STEM skills helpful? Why?

You could extend this by taking any one of the associated jobs and placing them at the centre of a spider diagram, and starting the process again.



Nina Gronw-Lewis, Glass Artist and Jewellery Maker



Studying science and maths can transform your career options. Future Morph: become someone.