Activity 8

How Does Stained Glass Get Its Color?

What Do You Think?

Stained glass windows adorn churches and other buildings around the world. Tiffany glass in lamp shades is now worth thousands of dollars.

- What gives colored glass its color?

Record your ideas about this question in your Active Chemistry log. Be prepared to discuss your responses with your group and the class.

Investigate

1. You will need several glass stirring rods or a nichrome wire, a small beaker of water, a Bunsen burner, borax, and several different metal compounds. You will use borax (sodium borate) as a glass substitute. This is because the temperatures needed to melt glass are usually higher than you can get in a science classroom.

The compounds that you will be testing will all be salts with various metal cations. The anion should be the same for each metal to ensure that the differences observed are due to the metal alone and not the anion. Some cation possibilities include: iron, cobalt, nickel, copper, manganese, strontium, and other transition metals.
Some anion possibilities include: oxides, nitrates, carbonates, chlorides.

Example: FeO, CoO, NiO, CuO, and MnO

2. Light a Bunsen burner and adjust the flame to get the inner blue cone. Dip one end of a stirring rod into water and then in borax. Heat the borax in the flame just above the inner blue cone. The borax will melt and should form a bead. Dip the stirring rod in the borax again and repeat until you have formed a good bead of borax “glass” on the stirring rod.

3. Once you have a good-sized bead on the stirring rod, flick the rod so that the bead falls off. You may try gently tapping the rod against a block of wood, or use some other technique that your teacher describes. The procedure takes some practice, but you can do it.

4. Repeat the procedure to make enough borax beads to test your metal samples.

   a) Describe the appearance of the borax bead in your Active Chemistry log. What color is it? Is it opaque, translucent or transparent?

5. Make a table similar to the one shown below in your Active Chemistry log. To test the metal compounds reattach the bead to the glass rod. Reheat the borax bead and quickly dip it in the compound to be tested. Heat just above the inner blue cone. Keep turning the stirring rod while heating, checking to see if the bead is taking up a color as you do so.

   a) Record the compound tested and the color produced in the table. Repeat the procedure with the rest of the compounds.

6. Test one or two of the compounds by heating them at the top of the outer flame. It is not as hot and does not have as much oxygen present.

   a) Is there a difference in the colors produced?

   b) How can you be certain that the metals in the compounds caused the colors that were produced?

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Safety goggles and apron must be worn at all times in a chemistry lab.

Follow all safety rules for working with open flames.

The borax beads will be very hot—do not touch them.

Do not inhale or ingest borax!

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METAL COMPOUNDS AND COLOR IN ART

Glass

Glass is used widely, not only in windows and artwork, but also in fiber optics. Most windows in houses are colorless and transparent; however, many beautiful windows use colored glass.
Ordinary glass is made by heating a mixture of silica (regular sand found on a beach), sodium carbonate, and calcium carbonate until it becomes a liquid and then allowing it to cool. If impurities are present, colors result. In fact, early glass derived its color from the impurities present when the glass was formed. In the 17th century, iron impurities in the sand used to make the glass, and sulfur from the smoke of the burning coal used to melt the glass often caused glass to be dark brown or green. Today, when you look at a cross section of a window, you will see a light green color. This is because of light absorption of the iron contained in the glass as an impurity.

To make different colored glass, metal oxides are added. To get the color blue, cobalt oxide and copper oxide are added, while chromium oxide and iron oxide are added to get the colors green and yellow, respectively. These compounds absorb different colored light from the white light passing through them and transmit the colors that you see.

Another popular red-colored glass is called ruby glass. It was invented in 1679 and contains gold chloride. Some of the elements were named after the colors of their salts, like rhodium, which makes a rose-colored glass (rhodon is Greek for rose). The salts of iodine are used in glass to give a purple color. Iodine is named after loeides, which is Greek for violet.

Ceramics

In ceramics, the chief source of color in glazes is from metallic oxides—iron, cobalt, copper, manganese, chromium, and nickel, to name a few. The colors obtained depend on concentrations, firing temperatures, and conditions of firing. Iron compounds produce amber to dark red, cobalt compounds produce blues, and copper compounds produce greens. Uranium compounds were once used to make a bright orange color (red “Fiesta Ware”) for tableware that was available in the 1950s and 1960s. Due to its radioactivity, it is no longer used! Combinations of compounds will produce other colors.

Glazes are suspensions of different clays and minerals in water. These are blended to melt at specific temperatures. Some glazes may contain lead compounds but these are not used when the ceramic object will be in contact with food. Glaze recipes are as varied as the artists who produce them. The firing of the glaze may cause unexpected results too. In addition to providing color to the ceramic objects, glazes also protect the ceramic and help to slow down deterioration.

Checking Up

1. List some metal oxides that are used in glazing.
2. Why are uranium salts no longer used in glazing?
3. Why is it a bad idea to use lead in ceramic objects that are used to serve food?
4. Why did early glass have a green tint to it?
**What Do You Think Now?**

At the beginning of the activity you were asked:

- **What gives colored glass its color?**

What are the similarities between the compounds that produce pigments and the compounds that produce colors in glass?

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**Chem Essential Questions**

**What does it mean?**

Chemistry explains a macroscopic phenomenon (what you observe) with a description of what happens at the nanoscopic level (atoms and molecules) using symbolic structures as a way to communicate. Complete the chart below in your *Active Chemistry* log.

<table>
<thead>
<tr>
<th>MACRO</th>
<th>NANO</th>
<th>SYMBOLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe some of the colors that were obtained by using different metal compounds.</td>
<td>At the molecular level, what causes different glass to have different colors?</td>
<td>How could you keep track of what combinations of compounds make desirable colors for glass works of art?</td>
</tr>
</tbody>
</table>

**How do you know?**

What evidence do you have to support the idea that the metal compounds are responsible for the colors seen?

**Why do you believe?**

You see colored glass objects around you every day. List several uses of colored glass in artistic work. What are some of the most vibrant colors? Can you suggest metals that might be used to get these colors?

**Why should you care?**

Using colored beads in your artwork could add beauty. Being able to describe the chemistry of the color would be fascinating.
Reflecting on the Activity and the Challenge

You have seen how color can be introduced into glass. You have learned that the compounds that produce the colors contain metal salts. The metal salts absorb certain colors and reflect others. Symbolically, the formulas of the compounds can be written. Works of art made of glass often include color. Artists are constantly experimenting with different compounds and different firing techniques to produce new colors and varied results. Combining different compounds can produce various colors. Think about how glass can enhance your Chapter Challenge.

Chem to Go

1. Glass artists in Colonial Williamsburg used local sand for glassmaking. The glass produced had a pale green color. What does this tell you about the sand that was used?

2. Use the Internet or another source to find out what compounds are used for the red, amber (yellow), and green-colored glass used in older traffic lights.

3. Use the Internet or another source to find the recipe for two different colors of glazes.

4. Preparing for the Chapter Challenge

Do an Internet search of glazes and find several recipes. List the “ingredients,” paying particular attention to the compounds that produce the colors. You will probably also see that glazes are prepared for different “cone” numbers. What does this tell the potter? How are the glazes applied? You might incorporate this information into your museum display.