

Colored Glass: The Basics

Colored glass ignites a child's imagination. Solid one moment, liquid the next, hard as a rock, translucent as a cloud, glass is a transformative art material and a bridge to other disciplines. Above all, glass sparks curiosity and encourages discussion.

A basic understanding of colored glass, its ingredients, and how it is made can help the teacher leading this exploration.

There are many varieties of glass. The most common is called simply Soda-Lime, a reference to its 2nd and 3rd major ingredients. This is the type of glass made at the Bullseye Glass factory.

GLASS IS MADE OF...

- **Sand** (SiO_2) 65 - 70%. Because it is the primary ingredient, sand is referred to as the glass former.
- **Soda or sodium** (Na_2O) about 15% of the recipe, is a flux. It lowers the melting temperature of the sand from about 3300°F to 2500°F, but it also leaves the glass unstable or water-soluble. So we add...
- **Lime or calcium oxide** (CaO), which makes up roughly 5-10%. This chemically stabilizes the glass.

A small percentage (~5%) of other minerals make up the remainder of the glass formula. Some of these minerals create color.

GLASS IS COLORED BY...

The addition of metal oxides, either singly or in combination, creates color within the glass body. Some of the more common coloring oxides are:

- **Chrome** (Cr) for green
- **Cobalt** (Co) for blue
- **Copper** (Cu) for turquoise blue
- **Gold** (Au) for cranberry red
- **Manganese** (Mn) for purple

More complex formulas will require a mix of oxides, such as:

- **Cadmium** (Cd), **selenium** (Se), and **sulfur** (S) for red
- **Cadmium** (Cd) and **sulfur** (S) for yellow
- **Chrome** (Cr), **cadmium** (Cd), and **sulfur** (S) for lime green

The amount of metal oxide needed to color glass can be miniscule. In the case of a gold ruby, it is 50 ppm (parts per million). In black glass, the metal oxides represent about 5% of the entire batch.

IS CLEAR A COLOR?

Technically, clear should be the absence of color, but look at the edge of a piece of window glass: the green you see is the presence of iron (Fe), the most common metal found in the earth's crust, and hence an inevitable impurity in sand. Removing the trace amounts of iron from sand is expensive and also unnecessary for most so-called clear glass uses, such as windows or bottles.

A clear glass without this green tint can be made by using an iron-free sand, which is extremely rare in nature and quite expensive.

Alternatively, the green in a basic clear glass recipe can be masked by adding a complimentary metal colorant to neutralize the green color, for example, manganese/purple, erbium/pink, or selenium/rose.

Colored Glass: The Basics (Continued)

TRANSPARENT OR OPALESCENT?

Art glass is often categorized according to how easy or difficult it is to see through. We speak in terms of its transparency or its translucency.

We see through a transparent glass with little distortion. Adding colorants will darken the glass and make images behind it more difficult to see, but it is still considered transparent.

Adding the element fluorine (F) in the form of calcium fluoride or sodium fluoride will give the glass a milky translucency. Light will still pass through it, but that light—and images behind the glass—will be much more distorted and diffuse.

These milky or opaque glasses are called opalescent in art glass manufacture.

ONCE MIXED TOGETHER, THE INGREDIENTS ARE MELTED

The mixture of sand and other components are called batch. Before it's loaded into the furnaces, the batch is mixed together in barrels or blenders.

The dry, powdery batch is shoveled—or charged—into natural gas-fired furnaces where it melts at approximately 2350°F for over 16 hours.

MELTED GLASS IS FORMED INTO SHEETS

The molten glass ladled out of the furnace has the consistency of honey. It is deposited onto a table where it is rolled into sheets, much as one might roll pie dough. This is called single-rolling.

In an alternate forming method, the molten glass passes between a pair of rollers—similar to the rollers on old style ringer washing machines—then extruded as a flat sheet onto a table.

Glass formed in this manner is called hand-cast or hand-rolled.

ANNEALING

Glass must be cooled slowly to room temperature in order to prevent the stress that will otherwise make it difficult to cut.

This controlled cooling is called annealing and is done over about 50 minutes on a continuously moving metal belt inside an oven called a lehr or an annealing oven.

Once at room temperature, the glass is trimmed to uniform size and crated or stored until it can be used by artists.

The information provided here is a very brief synopsis of glassmaking at one art glass factory. We hope it is useful as a general framework for leading a discussion about the material.

To learn more about the making of art glass and to watch the process at the Bullseye factory, view the video *What Is Glass?* on our website at:

www.bullseyeglass.com/education/what-is-glass.html

Bullseye Glass Co. in Portland, Oregon has produced hand-cast colored glass for artists since 1974. Started by three art school graduates, the factory runs a comprehensive research and education program alongside its glassmaking operation, hosts students and professional artists in on-site residencies, and exhibits fine art in glass and other media at its Portland gallery.

The company is currently broadening its educational programming to reach students in grades K-8.

To learn more about Bullseye, visit:

www.bullseyeglass.com and www.bullseyegallery.com