Glass Colors

Glass Engineering 150:312
Materials Science & Engineering

Professor Richard Lehman
CCR-103
School of Engineering
Colored Glass

- Coloring Mechanisms
  - Chemical Solution
  - Colloidal Coloring Centers

- Color Matching Issues

- Decolorizing

- Methods of Manufacture
  - Tank Operations
  - Color Feeder
  - Hand Shop Techniques
Glass Coloring Mechanisms

- Solution Colors - elements in chemical solution

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanadium</td>
<td>yellow-green</td>
</tr>
<tr>
<td>Chrome</td>
<td>emerald green</td>
</tr>
<tr>
<td>Iron</td>
<td>Coke bottle green</td>
</tr>
<tr>
<td>Manganese</td>
<td>amethyst</td>
</tr>
<tr>
<td>Cobalt</td>
<td>violet blue</td>
</tr>
<tr>
<td>Copper</td>
<td>greenish blue to blue</td>
</tr>
<tr>
<td>Nickel</td>
<td>grayish brown</td>
</tr>
<tr>
<td>Selenium</td>
<td>salmon pink</td>
</tr>
<tr>
<td>Cerium-Titanium</td>
<td>yellow</td>
</tr>
<tr>
<td>Neodymium</td>
<td>dichroic violet-pink</td>
</tr>
<tr>
<td>Uranium</td>
<td>yellow (fluorescent)</td>
</tr>
</tbody>
</table>
Glass Coloring Mechanisms - cont’d

- Colloidal Colors - color effect due to colloidal coloring centers in the glass.

<table>
<thead>
<tr>
<th>Element</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe-S</td>
<td>Amber</td>
</tr>
<tr>
<td>Au</td>
<td>Ruby</td>
</tr>
<tr>
<td>Cu-Sn</td>
<td>Ruby</td>
</tr>
<tr>
<td>Cd-S</td>
<td>yellow</td>
</tr>
<tr>
<td>Cd-Se-S</td>
<td>Orange and Red</td>
</tr>
<tr>
<td>F</td>
<td>Opal</td>
</tr>
</tbody>
</table>
Glass Coloring Mechanisms -cont’d

• “Striking” colors - refers to colors that form their colloidal coloring centers during a secondary or extended heat treatment.

• Opals, copper ruby and cadmium red glasses are striking colors.
Glass Coloring Mechanisms -cont’d

• Color Matching - solution colors can be combined for color matching. Popular color systems include:

<table>
<thead>
<tr>
<th>Element Pair</th>
<th>Color Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu-Cr</td>
<td>Aqua, Teal, Turquoise</td>
</tr>
<tr>
<td>Co-Cr</td>
<td>Midnight Blues</td>
</tr>
<tr>
<td>Cu-Co</td>
<td>Blues</td>
</tr>
<tr>
<td>Mn-Ni</td>
<td>Gray to Black</td>
</tr>
<tr>
<td>Co-Mn</td>
<td>Blue-Purples</td>
</tr>
</tbody>
</table>
Glass Color Matching Issues

- Color will vary with glass matrix.
- Colors will vary with tank operating conditions. Temperature and tank re-doxx can shift oxidation states, change colloidal coloring centers, and volatilize coloring elements.
- Not all colors can be matched in glass.
Glass Decolorizing

- Decolorizing refers to minimizing the appearance of the green color imparted to clear glass by trace levels of Iron.

- Chemical decolorizing is accomplished by adding oxidizers. Fe$_2$O$_3$ imparts less color than FeO.

- Physical decolorizing alters the color towards neutral gray by adding red and blue components to the glass, typically Co and Se.
Manufacture - Colored Tank Glass

• Entire glass tank is filled with colored glass.

• Used for high volume manufacture
  – Beverage containers including green, brown and cobalt blue.

• Make colors that can not be made in a color feeder because of tank design, color loading or lack of technology.
  – copper ruby, cerium yellow, opal
Manufacture - Color Feeder Glass

- Tank is filled with clear glass and color concentrate (frit) is introduced into one feeder.
- Significantly reduces time required for color changes and adjustments.
- Not capable of making all colors.
- Commonly used for blue, green, aqua, amethyst, pink.
Manufacture - Color Feeder Layout
• Small tank color production.

• Glass powder or chips are introduced to the surface of the gob. Color diffuses into the surface as the gob is re-heated and worked. Color has mottled appearance.

• Heavy color streaks can be introduced using colored rods.
Cobalt Blue
Chromium Green
Dark Chromium Green
[Trace Co, Cu]
Titanium
Cerium Yellow
Uranium and Praseodymium with UV illumination
Manganese Purple
[Trace Co]
Neodymium Under Tungsten Lighting
Neodymium Under Daylight
Selenium Rose Plate and Jar Compared With Frosted Se/Neodymium Glass
Copper Tin Red
Cadmium Sulfide Red
Partially and Fully Struck
Soda Lime Amber Glass [top three] FeS

Borosilicate Amber Glass Fe, Mn
Marpal Glass:
Fluoride opal with cobalt frit
Flame Reduction of Copper Jar to Produce Copper Metal Surface Flash
3 Purple Nickel Lead
16 Blue Co SLS
Blue Co Lead
6  Turquoise  Copper  Lead
18  Aqua, Cr-Cu, SLS
20 Emerald Cr SLS
7 Olive Cr, Mn Lead
22 Green, dead leaf Cr, Mn SLS
<p>| 9 | Yellow | Se | Lead |</p>
<table>
<thead>
<tr>
<th>11</th>
<th>Peach</th>
<th>Se, Er</th>
<th>Lead</th>
</tr>
</thead>
</table>
12 Amethyst Mn Lead
Hand Blown Bowl -- Blue/Green Mottle
Leerdam Vase
Nachtmann Case Crystal
Paperweight, Santa Fe, NM
Orrefors Bowl