Chapter 14

Glass

“There is no den in the wide world to hide a rogue. Commit a crime and the earth is made of glass.”

—Ralph Waldo Emerson
Glass Analysis

Students will learn:

- The difference between physical and chemical properties.
- How glass can be used as evidence.
- How individual evidence differs from class evidence.
- The nature of glass.
- How to use the properties of reflection, refraction, and refractive index to classify glass fragments.
Glass Analysis

Students will be able to:

- Make density measurements on very small particles.
- Use logic to reconstruct events.
- Use technology and mathematics to improve investigations and communications.
- Identify questions and concepts that guide scientific investigations.
Characteristics of Glass

- Hard, amorphous solid
- Usually transparent
- Primarily composed of silica with various amounts of elemental oxides
- Brittle
- Exhibits conchoidal fracture
Common Types

- **Soda-lime**—used in plate and window glass, glass containers, and electric light bulbs
- **Soda-lead**—fine table ware and art objects
- **Borosilicate**—heat resistant, like Pyrex
- **Silica**—used in chemical ware
- **Tempered**—used in side windows of cars
- **Laminated**—used in the windshield of most cars
Physical Characteristics

- **Density**—mass divided by volume
- **Refractive index (RI)**—the measure of light bending due to a change in velocity when traveling from one medium to another
- **Fractures**
- **Color**
- **Thickness**
- **Fluorescence**
- **Markings**—striations, dimples, etc
<table>
<thead>
<tr>
<th>Type of Glass</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>window</td>
<td>2.46-2.49</td>
</tr>
<tr>
<td>headlight</td>
<td>2.47-2.63</td>
</tr>
<tr>
<td>pyrex</td>
<td>2.23-2.36</td>
</tr>
<tr>
<td>lead glass</td>
<td>2.9-5.9</td>
</tr>
<tr>
<td>porcelain</td>
<td>2.3-2.5</td>
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</tbody>
</table>
Determination of Refractive Index

- **Immersion method**—lower fragments into liquids whose refractive index is different.
- **Match point**—when the refractive index of the glass is equal to that of the liquid
- **Becke line**—a halo-like shadow that appears around an object immersed in a liquid. It disappears when the refractive index of the liquid matches the refractive index of the glass fragment (the match point)
Determination of Refractive Index

- The refractive index of a high boiling liquid, usually a silicone oil, changes with temperature.
- This occurs in an apparatus called a hot stage which is attached to a microscope. Increasing the temperature allows the disappearance of the Becke line to be observed.
- At match point, temperature is noted and refractive index of the liquid is read from a calibration chart.
The Becke line is a “halo” that can be seen on the inside of the glass on the left, indicating that the glass has a higher refractive index than the liquid medium. The Becke line as seen on the right is outside of the glass, indicating just the opposite.
# Refractive Index

<table>
<thead>
<tr>
<th>Liquid</th>
<th>RI</th>
<th>Glass</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1.333</td>
<td>Vitreous silica</td>
<td>1.458</td>
</tr>
<tr>
<td>Olive oil</td>
<td>1.467</td>
<td>Headlight</td>
<td>1.47-1.49</td>
</tr>
<tr>
<td>Glycerin</td>
<td>1.473</td>
<td>Window</td>
<td>1.51-1.52</td>
</tr>
<tr>
<td>Castor oil</td>
<td>1.82</td>
<td>Bottle</td>
<td>1.51-1.52</td>
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<tr>
<td>Clove oil</td>
<td>1.543</td>
<td>Optical</td>
<td>1.52-1.53</td>
</tr>
<tr>
<td>Bromobenzene</td>
<td>1.560</td>
<td>Quartz</td>
<td>1.544-1.553</td>
</tr>
<tr>
<td>Bromoform</td>
<td>1.597</td>
<td>Lead</td>
<td>1.56-1.61</td>
</tr>
<tr>
<td>Cinnamon oil</td>
<td>1.619</td>
<td>Diamond</td>
<td>2.419</td>
</tr>
</tbody>
</table>
Fracture Patterns

- Radial fracture lines radiate out from the origin of the impact; they begin on the opposite side of the force.

- Concentric fracture lines are circular lines around the point of impact; they begin on the same side as the force.

- 3R rule—radial cracks form a right angle on the reverse side of the force.
Sequencing

- A high velocity projectile always leaves a hole wider at the exit side of the glass.
- Cracks terminate at intersections with others. This can be used to determine the order that the fractures occurred.
It is possible to determine the order cracks occurred in, because new cracks stop when they hit old cracks.
What direction, and in what order?
Glass as Evidence

- Class characteristics; physical and chemical properties such as refractive index, density, color, chemical composition
- Individual characteristics; if the fragments can fit together like pieces of a puzzle, the source can be considered unique
Considerations for Collection

- Collector should separate multiple broken glass sources based on physical properties.
- The inside and outside surfaces of the sample should be labeled if a determination of direction of breakage or reconstruction of the pane is desired.
A sample should be collected from various locations throughout the broken portion of the object in order to be as representative as possible, and with consideration being given to the presence of other types of evidence on that sample (e.g., fibers, blood).

Any glass samples collected should be documented, marked (if necessary), packaged in a box, and labeled.