Identification of Glass Samples by Their Refractive Index

References

Meloan, Clifton E.; James, Richard E.; Saferstein, Richard. Refractive Index (RI) of Glass Fragments. *Criminalistics: An Introduction to Forensic Science, Lab Manual*, 6th edition; Prentice-Hall: Upper Saddle River, NJ, 1998; pp 29-35.
Miller, Elmer T. Forensic Glass Comparisons. In *Forensic Science Handbook*; Richard Saferstein, Ed.; Prentice Hall: Englewood Cliffs, NJ, 1982; pp 139-183.

Goal

To compare known and questioned pieces of glass and to determine if they could have a common origin.

Suggested Methods of Analysis

Optical microscopy with a sodium vapor lamp

Materials

Glass samples stored in sealable plastic bags

Collect separately pieces of windshield glass, headlamp glass, bottle glass, etc. You should be able to collect free samples from a junk yard or collision repair facility.

Full set of refractive index liquids
Microscope slides

Preparing the Evidence

From the suspects: Windshield or headlamp glass from different automobiles should be assigned to each of the suspects. Put two small pieces of each glass into separate marked, sealable, plastic bags.

From the crime scene: Place a few small pieces of headlamp glass from one of the suspects and some bottle glass on a roadside. Sweep up the glass and accompanying debris, and store it in a marked, sealable, plastic bag.

Processing the Glass Samples

Separate glass from the scene from any other debris present and rinse it with deionized water. Examine by eye the glass from the crime scene and attempt to differentiate the pieces by their source(s). It may not be possible to tell how many kinds of glass are present by simple visual inspection.

Break off some small pieces of glass (one or two fragments approximately 1/4" square will do) from the larger pieces found at the scene. Do not mix glass from different pieces as you do not know if they come from the same source or not. Rinse the fragments again with deionized water and place them in a beaker of concentrated nitric acid for thirty minutes. Rinse three times with deionized water and then with ethanol. Next place the beaker containing the glass in an 80^{o} C oven for approximately ten or fifteen minutes to dry the sample.

Place a piece of clean glass in a plastic weighing boat on a plastic tray or cutting board. Nest another clean weighing boat on top of the first one containing the sample. Use a hammer to smash the sample into smaller pieces. The glass will cut through the plastic if care is not taken. The best way to crush the glass is to strike directly on top of the sample, firmly, and then reposition the sample in the weighing boat so that no holes are created. It is possible to get three good blows in one weighing boat, which should be enough to produce some very fine dust. This dust is used for the refractive index measurements and for the magnesium analysis.

Prepare the suspect glass samples in the same way. However, as all the glass in each sample is known to come from the same source, the chips from different glass fragments within a sample may be mixed.

Determining the Refractive Index of Glass

Turn on the sodium lamp and allow it to warm up. The lamp is ready to use when the light is yellow-orange instead of pink. Position the lamp in front of the microscope's mirror. Use a diffuser or layers of Kimwipe to reduce the brightness of the light. The aperture on the microscope should be small.

Carefully wipe the spatula and tweezers you will use to manipulate glass fragments with a Kimwipe to remove any dust or glass particles that may be on them. Place a few glass particles from your sample on a fresh microscope slide. You should be able to fit two samples on each slide, so put the particles to one end or the other of the slide. A set of refractive index liquids are provided; choose one from the low end of the range and one from the high end (1.46 and 1.54). These liquids have lower and higher refractive indexes, respectively, than any of the glass samples. Use one refractive index liquid on each group of particles. Touch the tip of the glass rod attached to the cap of the liquid's bottle to the microscope slide close to the glass particles. Avoid picking up the particles with the rod, but be sure you cover most or all of the particles with refractive index liquid. Label the slide with the identification of the glass sample and the refractive index of the two liquids used.

Place the slide on the stage of the microscope while the microscope is set to lower (e.g. 10x) magnification. Look at one of the samples, and search in the liquid for glass chips. When you have found a reasonably sized chip, position it in the center of the viewing field and bring it into clear focus. Switch to higher (e.g. 50x) magnification. Look at the glass chip. You will see the darker outline of the chip and you will see a light line or halo (called the Becke line). The halo will appear to move in and out of the chip outline as you adjust the fine focus dial. Turning the fine focus dial away from you (clockwise looking at the right-hand dial) makes the distance between the magnifier and the sample larger; if the light-colored halo goes into the border of the chip as the distance gets larger, then the refractive index of the glass chip is larger than the refractive index of the liquid. Turning the fine focus dial towards you (counterclockwise) makes the distance between the magnifier and the sample smaller. If the light-colored halo goes into the border of the chip as the distance gets smaller, then the refractive index of the glass chip is smaller than the refractive index of the liquid. Practice with the very high and very low refractive index liquids until you are sure you can determine whether the refractive index of the chip is higher or lower than the refractive index of the liquid in which it is immersed.

When you are confident of your microscopic work, prepare a fresh slide with a liquid that has a refractive index somewhere in the middle of the range. Using the information you gather from each observation and choosing subsequent refractive index liquids wisely, determine the refractive index of the sample to within 0.200 units. You should not have to use more than three or four different liquids. For instance, if you determine the refractive index of a glass sample is greater than 1.476 but less than 1.480, you may report its refractive index as 1.478 without further testing. If you try a refractive index liquid and can barely see the chips in the glass then you may have perfectly matched the refractive index of the liquid to the glass, and can report this. However, it would be best if you checked this assumption by bracketing the refractive index value with other observations; e.g. if by luck you first tried the liquid of refractive index 1.478 and saw no chips, you should make sure that you also find the sample has a refractive index greater than 1.476 and less than 1.480. Otherwise you might not have found any chips at all and mistakenly believed that you had matched the refractive index.

Table 1. Index of Refraction Ranges for Several Types of Glasses

Glass	Index of Refraction
Headlight glass	1.47-1.49
Television glass	1.49-1.51
Window glass	1.51-1.52
Bottles	1.51-1.52
Ophthalmic lenses	1.52-1.53

Table taken from Saferstein, R., Criminalistics Lab Manual, p. 30 (reference above).

Table 2. Index of Refraction for Specific Glasses

Glass	Index of Refraction
Windshield glass 1	1.518
Windshield glass 2	1.520
Headlight glass from Toyota Celica	1.478
Headlight glass from Chevrolet Eurosport	1.488
Headlight glass from Oldsmobile Cutlass Ciera	1.488
Headlight glass from Toyota Corolla	1.478
Bottle glass from Lipton Iced Tea	1.524