6.1 Introduction to Glass Analysis and Terminology

6.1.1 Introduction

A primary objective of a forensic glass examination is to compare glass specimens to determine if they can be discriminated using their physical, optical or chemical properties (for example, color, refractive index (RI), density, elemental composition). If the specimens are distinguishable, except for acceptable and explainable variations, in any of these observed and measured properties, it may be concluded that they did not originate from the same source of broken glass. If the specimens are indistinguishable in all of these observed and measured properties, the possibility that they originated from the same source of glass cannot be eliminated.

6.1.2 Terminology

Annealing is the process of reducing residual strain in glass by controlled heating and cooling.

Becke line is the bright halo near the edge of a transparent particle immersed in a medium. The halo moves with respect to that edge as the focal plane of the microscope is changed.

Becke line method is a method for determining the refractive index of a transparent particle relative to its surrounding medium by noting the direction that the Becke line moves when the distance between the objective of the microscope and the preparation is changed. The Becke line will always move toward the higher refractive index medium when the distance is increased and will move toward the lower refractive index medium when the distance is decreased from the point of critical focus.

A **conchoidal** type of fracture is observed when glass breaks to give irregularly curved and usually striated surfaces.

Container glass is a type of glass for the production of glass containers, such as bottles, jars, drinkware, and bowls.

Dispersion is the change in refractive index with a change in wavelength of illumination. Commonly referred to as V, relative dispersion is a measurement of the difference between the refractive index at different wavelengths of light, typically nC(486nm), nD(589nm), and nF(656nm), mathematically expressed as V=(nD-1)/(nF-nC).

Etching is a surface design or pattern produced by the application of a corrosive acid.

Flat glass is a type of glass, initially produced in plane form, commonly used for windows, glass doors, transparent walls, and windshields. Also known as sheet glass, glass pane, and plate glass.

Frosting is a finely grained, slightly roughened surface texture.

Float glass is a sheet of glass made by floating molten glass on a bed of molten metal (typically tin).

Glass is an inorganic product of fusion that has cooled to a rigid condition without crystallizing.

Interferometry is the use of light interference patterns for the evaluation of very small linear displacements (e.g., the assessment of a glass fragment surface for flatness or curvature).

Isotropy is the property of having the same refractive index regardless of the direction of vibration of light passing through the material. An isotropic particle will exhibit extinction at all orientations between crossed polars.

Match point is any combination of temperature and wavelength, at which two media have indistinguishable refractive indices. At the match point, the glass will exhibit minimum contrast and visibility.

Mirror region is the smooth portion of the crack surface that exhibits a mirror-like reflection when viewed using low power magnification.

Mold marks are the transfer impressions present on the surface of a molded glass object resulting from direct contact between the mold and the molten glass.

Ream is an imperfection, nonhomogeneous layers in flat glass. Rouge pits are defects on the glass surface containing residual rouge from polishing.

Polarized light microscope (PLM) is a microscope equipped with two polarizing elements, one (polarizer) located between the light source and the sample and the other (analyzer) between the sample and the observer.

Refractive index for a particular transparent medium is the ratio of the speed of light in one media compared to another, mathematically expressed as ni = v1/ v2, where refractive index = ni

Tempered glass is a type of safety glass produced by thermal or chemical treatments that increase its strength by putting the outer surfaces into compression and the inner surfaces into tension. When broken, tempered glass produces diced fragments rather than jagged shards. Also known as toughened glass.

6.1.3 Reagents

- Silicone Oils – e.g., Locke Scientific Oils A, B, and C
- Solvents – e.g., acetone, ethanol, hexanes, methanol, nitric acid, water

6.1.4 Equipment

- Stereomicroscope

- Polarizing light microscope
- Phase contrast microscope
- Microscope hot stage
- Refractive Index Measurement System (e.g., GRIM3)
- Micro X-ray fluorescence (uXRF) spectrometer
- Scanning electron microscope – energy dispersive spectrometer (SEM-EDS)
- Kapton film
- Adhesive with low heavy elemental content
- Calipers/micrometer
- Shortwave UV light

6.1.5 Types of Glass Examinations

6.1.5.1 Collection and Documentation

Includes recovery of apparent glass fragments from evidentiary items.

Observe evidentiary items using appropriate lighting conditions (spotlight, flashlight, stereomicroscope, etc.).

Recover/collect glass samples by manual removal with forceps, tape lifting, shaking out, or by gentle scraping.

Care should be taken when handling known and questioned samples:

- The examiner shall change gloves and clean their tools between examining/handling the evidence from the known source and the questioned evidence.
- Ideally, different tools should be used for the known and questioned samples, but at a minimum, the tool should be wiped clean and examined for cleanliness with a stereoscope before use on an evidence item.
- The examiner shall change the examination paper between questioned glass and known glass exhibits. The examiner may change the paper between multiple victim, suspect or scene items, as necessary.
- Make note of collection method, visible fragments, the location from which they were obtained, and any other observations. Collect into a paperfold or other container that will not leak trace particles.

Also see **Trace Evidence Sampling and Sample Selection Information** pertaining to glass.

6.1.5.2 Glass Screening

Includes utilizing the following observations and comparisons, for making exclusionary or non-exclusionary conclusions regarding samples (ex: Q & K) - See 6.2.1 Glass Screening:

- Color, tint and texture
- Relative thickness
- Fluorescence
- Isotropic qualities

6.1.5.3 Full analysis

Includes the above listed observations (when appropriate) in addition to refractive index and elemental comparisons (when possible).

6.1.6 Sample Cleaning:

For some examinations, it is often necessary to clean the glass samples. Confirm particles as being isotropic prior to cleaning, using polarized light microscopy.

As samples are being cleaned in a solvent, watch sample as it is placed into the solvent; perform careful cleaning agitation, check stirrer for adhering particles; check sample immediately after solvent evaporation.

Clean the sample to remove any surface contamination. Cleaning may include washing samples with soap and water, with or without ultrasonication, and rinsing in water, followed by rinsing in acetone, methanol, or ethanol, and drying. Soaking in various concentrations of nitric acid for 30 minutes or longer and rinsing with deionized water and ethanol and drying prior to analysis removes most surface contamination without affecting the measured concentrations of elements inherent in the glass. However, the use of nitric acid may remove any surface coating that may be present.