Initial Examinations of Glass

Scientific Working Group for Materials Analysis (SWGMAT)

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1. Scope

This document describes the determination of color, fluorescence, surface features, curvature, and thickness as they relate to forensic glass analysis.

2. Reference Documents

2.1. Scientific Working Group for Materials Analysis Documents

Trace evidence recovery guidelines
Quality assurance guideline

2.2. American Society for Testing and Materials Standard

C1036 *Standard Specification for Flat Glass*

3. Terminology

Colorimetry is an analytical method for measuring the color intensity of a substance.

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

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

Frosting is a finely grained, slightly roughened surface texture.

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.

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 microsope (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.

Polish lines are striation marks produced on the glass surface by polishing.

4. Summary of Guideline

Color, fluorescence, surface features, curvature, and thickness can be measured by microscopic and macroscopic methods. The measurements can be used to discriminate among different glass sources.

5. Significance and Use

At a minimum, a forensic glass examiner must identify an unknown material as glass because many materials can be mistaken for glass. Following identification, as many features as possible should be determined to characterize the glass and discriminate between sources. For example, two fragments differing in color can be excluded as originating from the same source, and no further examinations are necessary.

6. Sample Handling

Proper sample preparation and technique are prerequisites for obtaining reliable results. See the *Scientific Working Group for Materials Analysis Collection, Handling, and Identification of Glass*.

7. Analysis

7.1. Appearance

7.1.1. Condition of the glass

The general condition of the glass should be visually inspected, using a stereomicroscope prior to cleaning. For many of the comparative examinations that follow, it is desirable to select glass fragments with edges that appear freshly broken. The relative sharpness of the edge, the appearance of conchoidal fracture, and transparency serve to recognize a freshly broken surface. The presence of freshly broken glass fragments on an item can be important when interpreting the significance of the evidence.

7.1.2. Color

Comparing color can distinguish between two or more sources of glass. Sample size may affect apparent color. Therefore, side-by-side comparisons should be made with fragments of approximately equal and sufficient size. The fragments should be visually compared on edge, over a white surface, using natural light. Viewing the glass in this manner allows for optimal color observation through the fragment. This will also allow the examiner to distinguish between the true color of the glass and the color of any coatings or thin films that may be on the surface of the glass. Observing the glass using both fluorescent and incandescent lighting may be useful in distinguishing different colors or tints. The use of a stereomicroscope may aid in observing the color of small fragments of glass. Significant color differences between glass fragments can be used as the basis for exclusion. It is usually not possible to compare the color of microscopic glass fragments due to insufficient color density. Colorimetric analysis is typically not performed due to this limitation.

7.2. Fluorescence

Fluorescence is determined by observing a glass fragment over a nonfluorescent background while illuminating it consecutively with short-wave (254nm) and long-wave (~350nm) ultraviolet light. The surface of float glass that was in contact with molten tin during manufacturing should fluoresce under short-wave ultraviolet light. Different colors of fluorescence have been observed from glass fragments under short-wave and long-wave ultraviolet light, consecutively. These should be noted for comparison purposes (Lloyd 1981).

7.3. Surface Features

Surface features of glass can be formed either intentionally or accidentally as a result of manufacturing and fabrication processes or during use. Surface features form another basis of comparison that can distinguish one source of glass from another. They may also serve as identifying features when examining the glass fragments for a fracture match when the feature is present on both fragments.

7.3.1. Coatings

Surface features imparted by the manufacturing process include coatings, thin films, and mirrored backings. A forensic glass examiner typically encounters thin films or coatings on architectural and automotive glass. These films are placed there to increase durability, to provide solar shading, for aesthetic reasons, or other purposes (Greenberg 1997). Thin films are composed of a wide variety of materials in single or multiple layers. They can be amorphous or polycrystalline. The thickness of coatings can range from nanometers, as in the case of thin films, up to one millimeter, as in the case of mirrored backings. Coatings are generally applied to the nonfloat side of flat glass but can be applied to either or both surfaces. It may not be possible to distinguish or identify films and coatings visually. Additional instrumental methods of analysis, such as X-ray fluorescence methods, X-ray diffraction, scanning electron microscopy, transmission electron microscopy, or differential interference contrast microscopy may be necessary to detect invisible coatings or distinguish between coatings that appear visually similar. Conductivity testing may be used to detect the presence of coatings on low emissivity glass. For a more complete treatment on coatings, see Bach and Krause (1997).

7.3.2. Manufacturing features

Examples of intentional surface features include etching, frosting, and texturing. Accidental surface features imparted to glass as a result of the manufacturing process include mold marks, ream, rouge pits, and polish lines. Container glass can have a distinct "orange peel" texture or other surface features that are imparted to the glass from the manufacturing process.

All of the above can be compared visually, usually with the aid of a stereomicroscope.

7.3.3. Postmanufacturing surface features

Additional surface features that can serve to distinguish between two fragments of glass include surface scratches, abrasions, pitting, and extraneous materials adhering to the glass that may have their own evidentiary value. Any of these features present on glass fragments should be examined and characterized prior to cleaning.

7.4. Curvature

Determination of a curved surface can help distinguish flat glass from other types of glass including container, decorative, and ophthalmic. If the fragments are large enough, this can be done with the aid of a stereomicroscope. Smaller fragments may require the use of interferometry to determine if a surface is not flat (Fox 1981; Locke 1984). Small glass fragments from the mirror region of the fracture may mimic surface fragments.

7.5. Thickness

Thickness can be a useful property in distinguishing between flat glass products because many glass products have thickness as specified by American Society for Testing and Materials C1036. Thickness measurements should be made only on fragments possessing both original parallel flat surfaces. To measure thickness, a micrometer or caliper with a precision of +/- 0.02mm or better should be used. Numerous fragments should be measured, if possible, to determine the variation in measured thickness. When two glasses show significant differences in thickness, as determined by the variation in the known-source glass, they can be eliminated as originating from the same source. When using thickness to classify glass into product categories, see American Society for Testing and Materials specifications.

8. Considerations

8.1. These properties can be used to exclude fragments from originating from a given source. When the initial examinations have not excluded fragments, then further examination is required.

8.2. Documentation should also include condition of recovered fragments, approximate size range, presence of original surfaces, indication of the quantity of debris collected from different locations, and the presence of nonglass material of potential evidential significance.

9. References

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