Designation: E2228 – 23a

An American National Standard

Standard Guide for Microscopical Examination of Textile Fibers[1]

This standard is issued under the fixed designation E2228; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard covers guidelines for microscopical examinations employed in forensic fiber classification, identification, and comparison. The microscopical examination of fibers includes the use of a variety of light microscopes, such as stereomicroscopes, compound microscopes, and comparison microscopes, as well as a variety of illumination types, such as bright field, polarized light, fluorescence, and interference. In certain instances, the scanning electron microscope can yield additional information. The particular test(s) or techniques employed by each examiner or laboratory will depend upon available equipment, examiner training, and the nature and extent of the fiber evidence.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard is intended for use by competent forensic science practitioners with the requisite formal education, discipline-specific training (see Practice E2917), and demonstrated proficiency to perform forensic casework.*

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D276 Test Methods for Identification of Fibers in Textiles (Withdrawn 2021)[3]

E620 Practice for Reporting Opinions of Scientific or Technical Experts

E1459 Practice for Physical Evidence Labeling and Related Documentation

E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory

E1732 Terminology Relating to Forensic Science

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

2.2 *AATCC Standards:*[4]

AATCC Test Methods 20 Fiber Identification: Qualitative

2.3 *Other Documents:*

ISO 17025 Testing and calibration laboratories[5]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology D123 and E1732.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anisotropic, adj*—a characteristic of an object in which the refractive index differs depending on the direction of propagation or vibration of light through the object. **(1)**[6]

3.2.2 *barrier filter, n*—a filter used in fluorescence microscopy that absorbs excitation energy that has been reflected by the sample, selectively transmitting only wavelengths of light greater than the cut-off wavelength, or within a specific wavelength range.

3.2.3 *Becke line, n*—the bright halo near the boundary of a fiber that moves with respect to that boundary as the microscope is focused through best focus when the fiber is mounted in a medium that differs from its refractive index. **(1)**

[1] This guide is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.15 on Trace.

Current edition approved May 1, 2023. Published May 2023. Originally approved in 2002. Last previous edition approved in 2023 as E2228 – 23. DOI: 10.1520/E2228-23A.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, http://www.aatcc.org.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[6] The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.2.4 *Becke line method, n*—a method for determining the refractive index of a fiber relative to its mountant by noting the direction in which the Becke line moves when the focus is changed.

(1)

3.2.4.1 *Discussion*—The Becke line always moves toward the higher refractive index medium (fiber or mountant) when focus is raised (stage is lowered) and towards the lower refractive index medium when focus is lowered (stage is raised). At the point where the index of the fiber matches the index of the mounting medium, the Becke line is no longer visible. The Becke line is generally viewed at a wavelength of 589 nm (the D line of Sodium [n_D]).

(1)

3.2.5 *birefringence, n*—the numerical difference in refractive indices (n) for a fiber, given by the equation:

$$|n\| - n\perp|$$

Birefringence (B) can be calculated by determining the retardation (r) and thickness (T) at a particular point in a fiber and by using the equation:

$$B = r\,(\text{nm})/1000T\,(\mu\text{m})$$

(1)

3.2.6 *comparison microscope, n*—a system of two microscopes positioned side-by-side and connected via an optical bridge so that two specimens are examined simultaneously in a single field of view in either transmitted or reflected light.

3.2.7 *compensator, n*—any variety of optical devices that can be placed in the light path of a polarized light microscope to introduce known, fixed or variable retardation in a specific vibration direction; the retardation and sign of elongation of the fiber can then be determined.

(2)

3.2.8 *compensator, full-wave (or red plate), n*—a compensator (usually a plate of gypsum, selenite or quartz) that introduces a fixed retardation between 530 to 550 nm (approximately the retardation of the first order red color on the Michel-Lévy chart).

(1, 2)

3.2.9 *compensator, quarter-wave, n*—a compensator (usually a mica plate) that introduces a fixed retardation between ~137–147 nm (approximately the retardation of first-order gray on the Michel-Lévy chart).

(1, 2)

3.2.10 *compensator, quartz wedge, n*—a wedge, usually cut from quartz, having continuously variable retardation extending over several orders (usually 3 to 7) of interference colors.

(1)

3.2.11 *compensator, Sénarmont, n*—a quarter-wave plate inserted above the specimen in the parallel "0" position with a calibrated rotating analyzer; measures low retardation and requires the use of monochromatic light.

3.2.12 *compensator, tilting (Berek), n*—a compensator typically containing a plate of calcite or quartz, which can be tilted by means of a calibrated drum to introduce incrementally variable retardation.

3.2.13 *cortex, n*—the main structural component of hair consisting of elongated and fusiform (spindle-shaped) cells; the cortex can contain pigment granules, air spaces called cortical fusi, and structures called ovoid bodies.

3.2.14 *crimp, n*—the curl, wave, or compression that is naturally occurring or otherwise imparted to a fiber.

3.2.15 *cuticle, n—in mammalian hair fibers*, the layers of flattened cells enclosing the cortex, which form an envelope of overlapping scales surrounding the fiber. **D123**

3.2.16 *delustrant, n*—a pigment, usually titanium dioxide, used to dull the luster of a manufactured fiber.

(3)

3.2.17 *dichroism, n*—the property of exhibiting different colors, especially two different colors, when viewed along different axes by plane polarized light.

3.2.18 *dislocations, n*—distinct features that occur in natural fibers (for example, flax, ramie, jute, hemp) in the shape of X's, I's, and V's that are present along the fiber cell wall; these features are often useful for identification.

3.2.19 *dispersion of birefringence, n*—the variation of birefringence with wavelength of light.

3.2.19.1 *Discussion*—When dispersion of birefringence is significant in a particular fiber, anomalous interference colors not appearing in the regular color sequence of the Michel-Lévy chart can result. Strong dispersion of birefringence can also interfere with the accurate determination of retardation in highly birefringent fibers.

3.2.20 *dispersion staining, n*—an optical staining technique in which colors are produced by the differential refraction of different wavelengths of light due to mounting the sample in a liquid having a different dispersion of refractive index.

(1)

3.2.20.1 *Discussion*—The procedure employs central or annular stops placed in the objective back focal plane of a microscope. Using an annular stop with the substage iris closed, a fiber mounted in a high dispersion medium shows a colored boundary of a wavelength where the fiber and the medium match in refractive index. Using a central stop, the fiber shows colors complementary to those seen with an annular stop.

3.2.21 *dye, n*—soluble substances that add color to textiles.

(3)

3.2.21.1 *Discussion*—Dyes are classified into groups that have similar chemical characteristics (for example, aniline, acid, and azo) and also by their method of application (for example, reactive or direct). They are incorporated into the fiber by chemical reaction, absorption, or dispersion.

(3)

3.2.22 *excitation filter, n*—a filter used in fluorescence microscopy that transmits specific bands or wavelengths of energy capable of inducing visible fluorescence in various substrates.

3.2.23 *exclusionary difference, n*—a difference in one or more characteristics between compared items that is sufficient to determine that the compared items did not originate from the