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Standard Guide for Tiered Approach to Detection and Characterization of Silver Nanomaterials in Textiles¹

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1. Scope

1.1 This guide covers the use of a tiered approach for detection and characterization of silver nanomaterials in consumer textile products, which can include some medical devices (for example, wound dressings or face masks), made of any combination of natural or manufactured fibers.

1.2 This guide covers, but is not limited to, fabrics and parts (for example, thread, batting) used during the manufacture of textiles and production of consumer textile products that may contain silver-based nanomaterials. It does not apply to analysis of silver nanomaterials in non-consumer textile product matrices nor does it cover thin film silver coatings with only one dimension in the nanoscale.

1.3 This guide is intended to serve as a resource for manufacturers, producers, analysts, policymakers, regulators, and others with an interest in textiles.

1.4 This guide is presented in the specific context of measurement of silver nanomaterials; however, the structured approach described herein is applicable to other nanomaterials in consumer textile products, including some medical devices.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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.*

1.7 *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.*

¹ This guide is under the jurisdiction of ASTM Committee E56 on Nanotechnology and is the direct responsibility of Subcommittee E56.06 on Nano-Enabled Consumer Products.

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2. Referenced Documents

2.1 ASTM Standards:²

D123 Terminology Relating to Textiles

D6413 Test Method for Flame Resistance of Textiles (Vertical Test)

2.2 AATCC Standards:³

AATCC 135 Dimensional Changes of Fabrics after Home Laundering

2.3 ISO Standards:⁴

ISO 10136-1 Glass and Glassware—Analysis of Extract Solutions—Part 1: Determination of Silicon Dioxide by Molecular Absorption Spectrometry

ISO 16140 Microbiology of Food and Animal Feeding Stuffs—Protocol for the Validation of Alternative Methods

ISO/IEC Guide 99 International Vocabulary of Metrology—Basic and General Concepts and Associated Terms (VIM)

ISO/TR 18196 Nanotechnologies—Measurement Technique Matrix for the Characterization of Nano-Objects

ISO/TS 80004-1 Nanotechnologies—Vocabulary—Part 1: Core Terms

2.4 U.S. Code of Federal Regulations:⁵

16 CFR Parts 1615 and 1616 Standards for the Flammability of Children's Sleepwear

3. Terminology

3.1 *Definitions*—For additional definitions related to textiles, see Terminology D123; for additional definitions related to nanotechnology, see ISO/TS 80004-1; and for additional definitions related to measurements, see ISO/IEC Guide 99.

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

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

⁵ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

3.1.1 *analyte*, *n*—element or constituent to be determined. **ISO 10136-1**

3.1.2 *consumer textile product*, *n*—textile product intended to satisfy human wants and needs. **D123**

3.1.3 *manufactured fiber*, *n*—class name for various genera of filament, tow, or staple produced from fiber-forming substances that may be: (1) polymers synthesized from chemical compound, (2) modified or transformed natural polymers, or (3) glass. **D123**

3.1.4 *measurand*, *n*—quantity intended to be measured or a quantity that is being determined by measurement. **ISO/IEC Guide 99**

3.1.5 *nanomaterial*, *n*—material with any external dimension in the nanoscale or having internal structure or surface structure in the nanoscale. **ISO/TS 80004-1**

3.1.6 *nanoscale*, *n*—range from approximately 1 to 100 nm. **ISO/TS 80004-1**

3.1.7 *natural fiber*, *n*—class name for various genera of fibers (including filaments) of (1) animal, (2) mineral, or (3) vegetable origin. **D123**

3.1.8 *qualitative method*, *n*—method of analysis whose response is either the presence or absence of the analyte detected either directly or indirectly in a certain amount of sample. **ISO 16140**

3.1.9 *quantitative method*, *n*—method of analysis whose response is the amount of the analyte measured either directly (enumeration in a mass or a volume), or indirectly (colour absorbance, impedance, etc.) in a certain amount of sample. **ISO 16140**

3.1.10 *textile*, *n*—general term for fibers, yarn intermediates, yarns, fabrics, and products that retain all the strength, flexibility, and other typical properties of the original fibers or filaments. **D123**

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *characterization*, *n*—identification and quantification of one or more relevant physical or chemical property values of the analyte.

3.2.2 *detection*, *n*—qualitative recognition of the presence of the target analyte in a sample.

3.2.3 *silver*, *n*—element with atomic number 47 that can be in the form of ions, metallic or zero-valent (Ag^0), alloys, composites, oxide, or salt compounds, or combination thereof.

4. Significance and Use

4.1 Natural and manufactured textiles fibers can be treated with chemicals to provide enhanced antimicrobial (fungi, bacteria, viruses) properties. In some cases, silver nanomaterials may be used to treat textile fibers (1).⁶ Silver nanomaterials are used to treat a wide array of consumer textile products, including, but not limited to, various clothing; primary garments (shirts, pants), outer wear (gloves, jackets), inner wear (socks and underwear), children's clothing (sleepwear); chil-

dren's plush toys; bath towels and bedding (sheets, pillows); and medical devices (for example, wound dressings and face masks) (2).

4.2 There are many different chemical and physical forms of silver that are used to treat textiles and an overview of this topic is provided in [Appendix X1](#).

4.3 Several applicable techniques for detection and characterization of silver are listed and described in [Appendix X2](#) so that users of this guide may understand the suitability of a particular technique for their specific textile and silver measurement need.

4.4 There are many different reasons to assay for silver nanomaterials in a textile at any point in a product's life cycle. For example, a producer may want to verify that a textile meets their internal quality control specifications or a regulator may want to understand the properties of silver nanomaterials used to make a consumer textile product under their jurisdiction or what quantity of silver nanomaterial is potentially available for release from the treated textile during the washing process or during product use. Regardless of the specific reason, a structured approach to detect and characterize silver nanomaterials present in a textile will facilitate measurements and data comparison. Detection and characterization of silver in textiles is one component of an overall risk assessment.

4.5 The approach presented in this guide (see [Fig. 1](#)) consists of three sequential tiers: obtain a textile sample (Section 7), detection of a silver nanomaterial (Section 8), and characterization of a silver nanomaterial (Section 9). If no forms of silver are detected in a textile sample using appropriate (fit for purpose) analytical techniques then testing can be terminated. If silver is detected, but present in a non-nanoscale form, the textile is a chemical or bulk silver-containing material. Silver ions may be released from silver-containing materials, and under reducing conditions these can transform into nanoscale silver-containing particles. If nanoscale silver is detected, one concludes that the textile contains a silver nanomaterial. Subsequent measurements can characterize the chemical and physical properties of the silver nanomaterial.

4.6 Numerous techniques are available to detect and characterize silver nanomaterials in textiles. The breadth of options can cause confusion for those interested in developing an analytical strategy and selecting appropriate techniques. Some techniques apply only to certain chemical forms of silver and all have limited ranges of applicability with respect to a measurand. No single technique is suitable to both detect and fully characterize silver nanomaterials in textiles. This guide describes and defines a tiered approach using commercially available measurement techniques so that manufacturers, producers, analysts, policymakers, regulators, and others may make informed and appropriate choices in assaying silver nanomaterials in textiles within a standardized framework. The user is cautioned that this guide does not purport to address all conceivable textile analysis scenarios and may not be appropriate for all situations. In all instances, professional judgment is necessary.

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