Scope

This document describes procedures used as well as the conclusions that can be reached from the microscopic examination, identification and comparison of fibers in the Trace Evidence Unit. It also addresses the color measurement of fibers using microspectrophotometry and the chemical analysis of fibers using Fourier Transform Infrared (FT-IR) spectroscopy. This procedure applies to fiber samples that have been previously removed from evidentiary items and have been mounted on glass microscope slides using the Guidelines for Trace Evidence Examination (TES01).

Safety Precautions

- While working with physical evidence, laboratory personnel will wear appropriate protective attire (at a minimum, laboratory coat, gloves, and hair net).
- Universal precautions will be followed.
- No specific hazards are associated with the microscopic examination techniques performed.

Materials Required

- Comparison microscope, magnification range from 50x to 600x
- Polarized light microscope, magnification range from 40x to 400x, with eyepiece reticle
- Fluorescence microscope, four filter combinations encompassing UV, Violet, Blue and Green excitation radiation
- Stereobinocular microscope, magnification range from 0.5x to at least 40x
- Craic QDI microspectrophotometer with a visible range of 400nm – 800nm
- Fourier Transform Infrared Spectrometer with microscope attachment
- Diamond compression cell
- Xylene substitute or reagent grade Xylene
- Glass microscope slides and cover slips
- Microscope camera
- Probe, scalpel, forceps
- Berek compensator (or equivalent compensator such as a sliding wedge)
- Full wave (lambda) plate

Standards and Controls

- **Microspectrophotometry (MSP)**
  Refer to TES07 - Microspectrophotometry for Fiber Color Analysis for the steps involved in the daily performance verification prior to running casework samples on the MSP.
- **Fourier Transform Infrared (FT-IR)**
  Refer to TES06 – FTIR Spectroscopy for Polymer Subclass Identification for the steps involved in the daily performance verification prior to running casework samples on the FT- IR.

Procedure

1 Documentation of Fiber Evidence

1.1 Based on an examination of the glass microscope slides for an item of evidence, the presence or absence of fibers can be determined. The absence of fibers may be documented in the case notes with a statement such as "no fibers were found", or, the absence of any reference to fibers on an item implies that no fibers are present. This documentation will be prepared for each item of evidence examined.

1.2 If fibers are present, they may be identified individually or collectively at the discretion of the examiner. Refer to the Abbreviation List for approved abbreviations for fibers in the *Laboratory Quality Assurance Manual* (current revision). At a minimum, a general statement regarding the presence of fibers will be documented in the case notes. This documentation will exist for each item of evidence examined.

2 Fiber Comparison

2.1 For fibers that are going to be compared to one another, the comparison microscope is the first instrument that is used. The fiber samples will be compared at the same time in the same field of view utilizing the comparison microscope.

2.2 If no differences are noted in general size, shape, configuration or color utilizing the comparison microscope, numerous microscopic characteristics and optical properties will be analyzed and used in the next step in the comparison process. Some of these characteristics apply only to manufactured fibers, and are identified below. The following is a list of the characteristics that will be analyzed, compared and documented utilizing either the comparison microscope or the polarized light microscope with a fluorescence attachment. This information will be documented in the case notes utilizing the Textile Fiber Comparison Properties form. If an unexplainable difference is found for any of these characteristics, the comparison process will cease and the fibers cannot be associated to each other. This information will be documented on the fiber chart.

- Fiber Color
    - Color may be uniform or may vary along the length of the fiber. Document the color and any apparent variation in the color, if present. This characteristic applies to both natural and manufactured fibers.

- Fiber Luster
    - The presence, absence and relative abundance of delustrant present in manufactured fibers will be documented. This characteristic applies only to manufactured fibers.

- Fiber Cross-Section
    - For manufactured fibers, document the apparent cross-sectional shape. This can be conducted via optical cross-sectioning or by physically cross-sectioning the fiber. This characteristic typically only applies to manufactured fibers, although it may be useful in the identification of certain types of natural fibers.
- Fiber Diameter
    - For manufactured fibers, the approximate diameter of fibers can be measured using an eyepiece reticle. If fiber diameter is variable within a sample, documentation of the diameter range is recommended. This characteristic typically only applies to manufactured fibers. The comparison of fiber diameter is easily accomplished using the comparison microscope and often there is no need to measure the fiber's diameter.
- Other Characteristics
    - Document any surface damage, manufacturing striations, or other characteristics noted in the sample.
- Becke Line
    - For manufactured fibers, the determination of n parallel and n perpendicular relative to Permount based on the direction of movement of the Becke line in relation to the fiber will be documented using plane polarized light. One can also use the Becke line method to determine the isotropic refractive index (the index the fiber has in normal light) relative to Permount. This is especially important when comparing two fibers using a comparison microscope. These characteristics typically only apply to manufactured fibers. The amount of contrast (distinctness of the edges of the fiber) of the fiber in Permount should also be noted when the Becke line is examined for all refractive indices.
- Retardation (Path Difference)
    - For manufactured fibers, the retardation (distance the slow ray falls behind the fast ray) will be estimated through the use of a Michael Levy chart, quartz wedge or Berek compensator (or equivalent). This characteristic typically only applies to manufactured fibers.
- Birefringence
    - For manufactured fibers, the birefringence can be estimated by dividing the retardation, or path difference, by the diameter of the fiber. A full-wave plate may be used to help determine the sign of

elongation. This characteristic typically only applies to manufactured fibers.

- Pleochroism (Dichroism)
    - The presence and/or degree of pleochroism present in a sample will be documented. This characteristic applies to both natural and manufactured fibers.

- Fluorescence
    - At each of the four excitation wavelengths (330-380 nm, 380-420 nm, 450-480 nm and 510-560 nm) the color and intensity or the absence of fluorescent emission will be documented. This characteristic applies to both natural and manufactured fibers.
- Other techniques
    - Other identification and comparison techniques such as micro-solubility examinations or drying twist test may be used as deemed appropriate by the examiner. The technique used and the results will be documented in the case notes.

3 Microspectrophotometric Analysis

If two fibers cannot be differentiated utilizing the characteristics listed above and if the fiber has been dyed, the fibers must be analyzed utilizing MSP. The use of the MSP may be necessary even if it appears that the fibers being compared have not been dyed.

Refer to TES07 - Microspectrophotometry for Fiber Color Analysis for the steps involved in running casework samples on the MSP.

4 FT-IR Analysis

If the fiber cannot be differentiated utilizing the characteristics listed above or by MSP analysis (if applicable), then the fibers may be analyzed utilizing FT-IR. The analysis involves two steps: a comparison of the known and/or questioned fibers to one another, and an identification of the polymeric material. This technique is limited to the analysis of manufactured fibers. Natural fibers are not typically analyzed utilizing FT-IR.

Refer to TES06 – FTIR Spectroscopy for Polymer Subclass Identification for the steps involved in running casework samples on the FT- IR.

5 Fiber Conclusions

5.1 If no differences are observed between the two fiber samples utilizing the applicable techniques outlined above, it can be concluded that the fibers are consistent with originating from the same source. A notation will be placed in the relevant portion of the case notes documenting this fiber association

(usually in the notes documenting the results of the general microscopic analysis for an item of evidence).

5.2 If an unexplainable difference is observed, then the fibers can be excluded as originating from the same source. This information will be documented in an appropriate place in the case notes (usually in the documentation of the microscopic characteristic or optical property that allowed the fibers to be excluded).

5.3 If no fiber associations are found in a case, a summary statement may be made in the notes documenting this. This is left to the discretion of the examiner. If no documentation exists to support a fiber association, it is implied that no fiber association exists.

6 Fiber significance

There are a number of factors that must be considered in assessing the significance or evidential value of a fiber association. Generally the significance is assessed by considering the probability that the matching fiber evidence is due to chance or that the fibers of unknown origin are present in a particular location by coincidence. This probability is directly related to the relative frequency of the fiber type involved in the association. Any information that reduces the relative frequency of a particular type of fiber increases the evidential value of matching fiber evidence. Initially it must be determined if a fiber is a common fiber type. If a common fiber type is involved in the association, this needs to be pointed out in the report. If the fiber is not a common fiber type then it can be the basis of a meaningful association. Generally, colored manmade fibers would fall into this category. If information is developed to show that a fiber type is uncommon, then that fiber type can be the basis of a very strong association. Other factors that may be considered in assessing the evidential value of the fiber evidence in a particular case are the number of fibers of the fiber type involved in the association, the number of different fiber types involved in the association, whether there is evidence of a cross transfer between two objects, the location of the recovered fibers, the number of non-matching fibers recovered, the potential for contamination in a case and the relationship between the items associated with the fiber evidence.

7 Fiber Confirmation

Fiber associations are confirmed by a second qualified examiner. A fiber confirmation encompasses a second analysis of the microscopic characteristics and optical properties (which will include comparison microscopy, polarized light microscopy and fluorescence microscopy) and a review of the results of the microspectrophotometry comparison. For manufactured fibers, the second confirmation also includes a review of the infrared spectroscopy. These confirmations are documented by the signature of the confirming examiner and the date of the confirmation on the Textile Fiber Association Form.

8 Calculations

Birefringence can be estimated by using the following equation. The estimation of the fiber birefringence also requires that the retardation and the fiber thickness be estimated.

$$\text{Birefringence} = \frac{\text{Retardation (nm)}}{\text{Thickness (nm)}}$$

Limitations

- When performing comparative fiber analysis, fiber samples must be examined in the same mounting medium.
- Dye identification and a determination of the number of different dyes used to color a fiber are not possible with MSP.

Comments

Not applicable.

Documentation

The following worksheet(s) shall be generated and managed:

Casework Documentation
Textile Fiber Comparison Properties Form
Textile Fiber Association Form

References

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- FT-IR User's Guide
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