DAUBERT ADMISSIBILITY PACKAGE FOR TAPE EVIDENCE

Scientific Working Group for Materials Analysis

Tape Subgroup

April 2012

This presentation is a general overview of a Daubert admissibility response. The presentation should be modified to fit an individual laboratory's protocol, jurisdiction and/or specifics relevant to a case. Instrumentation depicted in this presentation should not be construed as an endorsement of a particular company.

Presentation Objectives

- Fundamentals of forensic tape examinations
- The Daubert Standard Criteria for Admissibility as it applies to tape

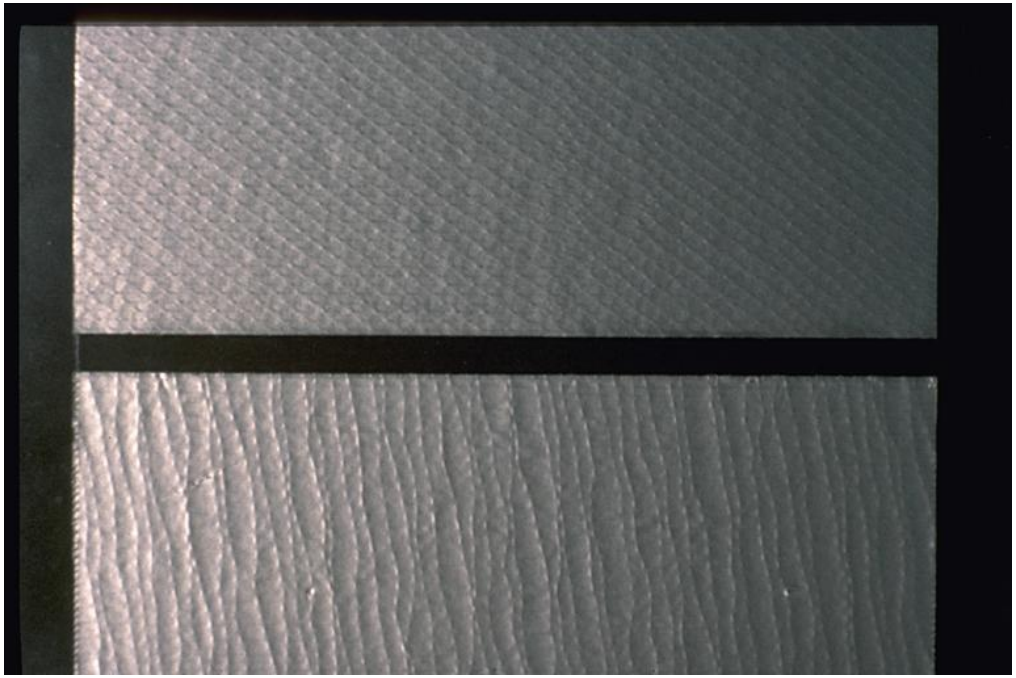
FUNDAMENTALS OF FORENSIC TAPE EXAMINATION

Pressure Sensitive Tape as Physical Evidence

- Comparisons between tapes recovered from possibly related sources (i.e., the scene and suspect's residence)
- Verifying a version of events
- Used as an investigative lead. (e.g., sequence of events, manufacturer sourcing)

Associative Evidence Examinations

Comparison of samples to determine if they share a common origin or if there are any distinguishing characteristics that would eliminate a questioned sample as coming from a known source.



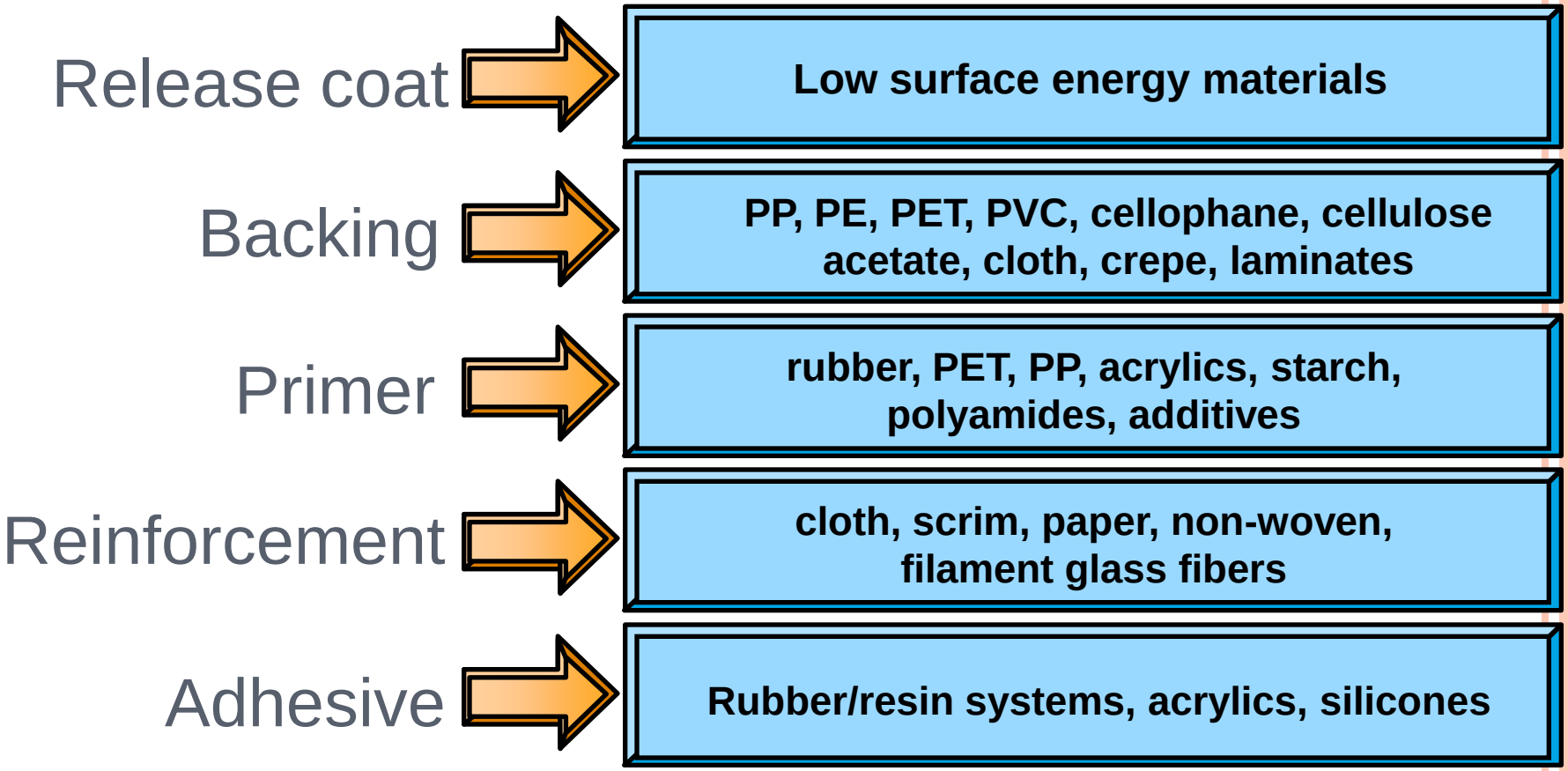
Sourcing

- Determining possible product information, manufacturing, and retailing sources may provide investigative lead information.
- Physical characteristics and compositional data are useful for technical inquiries to tape manufacturing companies, comparisons with various brands of tape at local outlets, and database searches.

Common classes of tape

- Duct tape
- Electrical tape
- Fabric tape
- Masking tape
- Office tape
- Packaging tape
- Strapping tape

TAPE CONSTRUCTION



NOTE: not all classes of tapes contain all of the listed tape layers.

Tape Variability

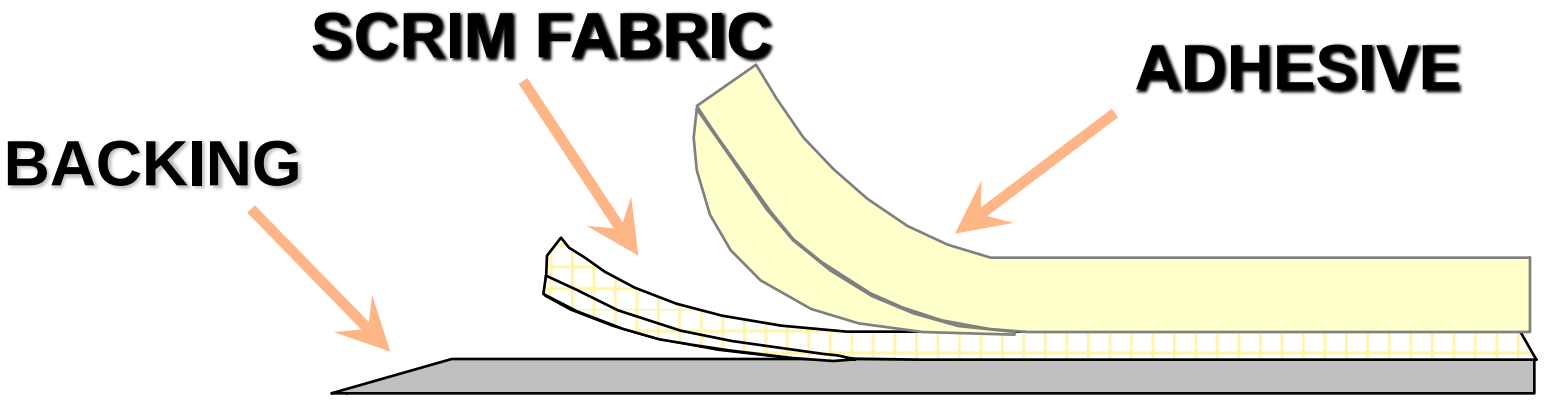
Some classes of tape are more variable than others. Typically, if the tape is more complex (more components or discriminating features), it may have more variability.

- Different rolls of the same class of tape can vary in physical construction and chemical composition.
- Physical and chemical characteristics are relatively consistent throughout a single roll of tape.

TECHNIQUES OF TAPE ANALYSIS

Physical match
Physical characteristics
Polarized Light Microscopy (PLM)
Fourier Transform Infrared Spectroscopy (FTIR)

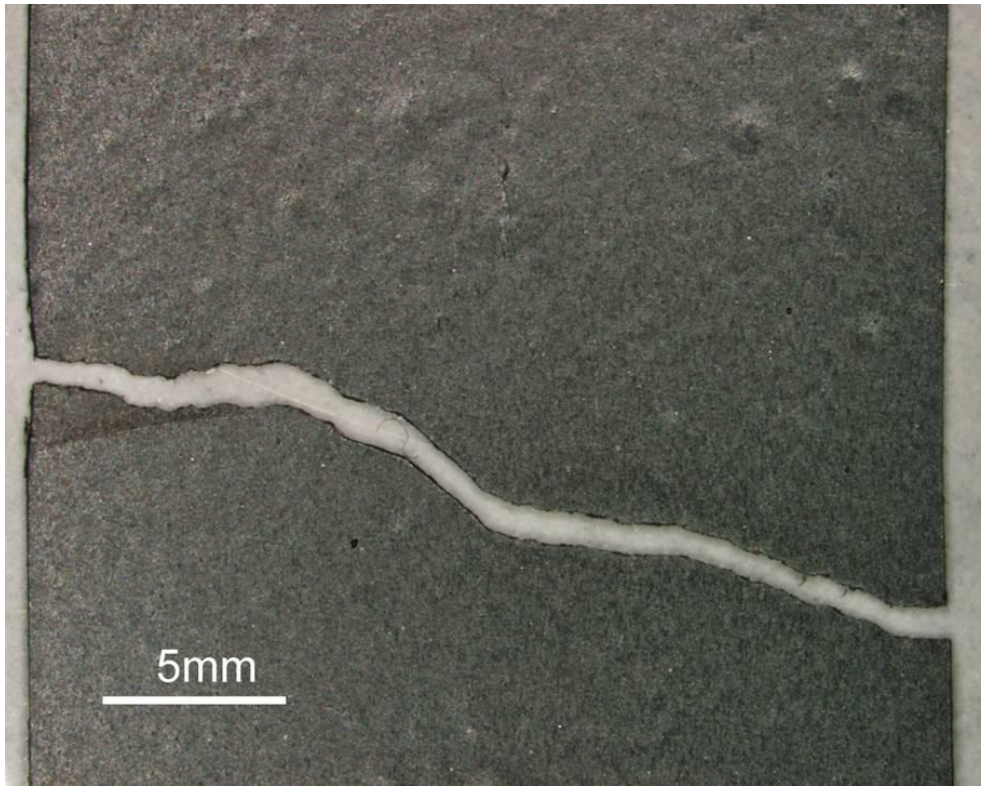
Elemental analysis
X-ray Diffraction (XRD)
Pyrolysis-Gas Chromatography (Py-GC)



Courtesy of Jerry Serra, consultant

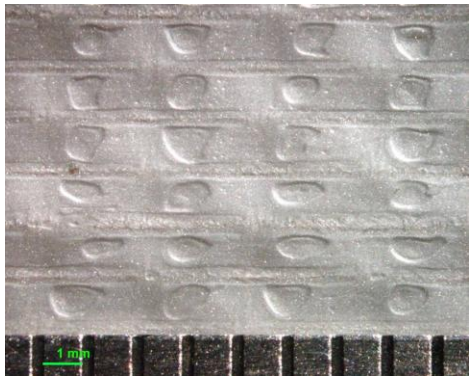
Physical Matches

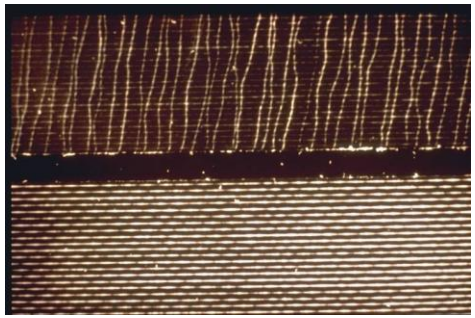
A tape end physical match is the most compelling type of association between two tapes.



Physical Characteristics

- Tape width
- Thickness: overall and backing
- Adhesive color
- Backing
  - Color
  - Surface characteristics
  - Layer structure (cross-section)
- Scrim
  - Fabric construction
  - Yarn count
  - Fiber examination
  - Fluorescence

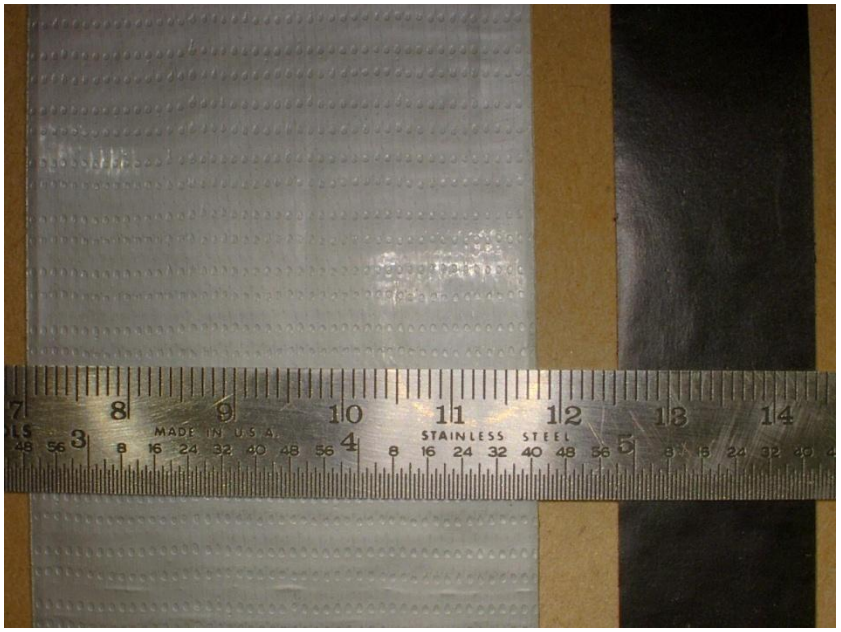




The SWGMAT Tape Subgroup has written *Guideline for Assessing Physical Characteristics in Forensic Tape Examinations* – accessible at www.swgmat.org

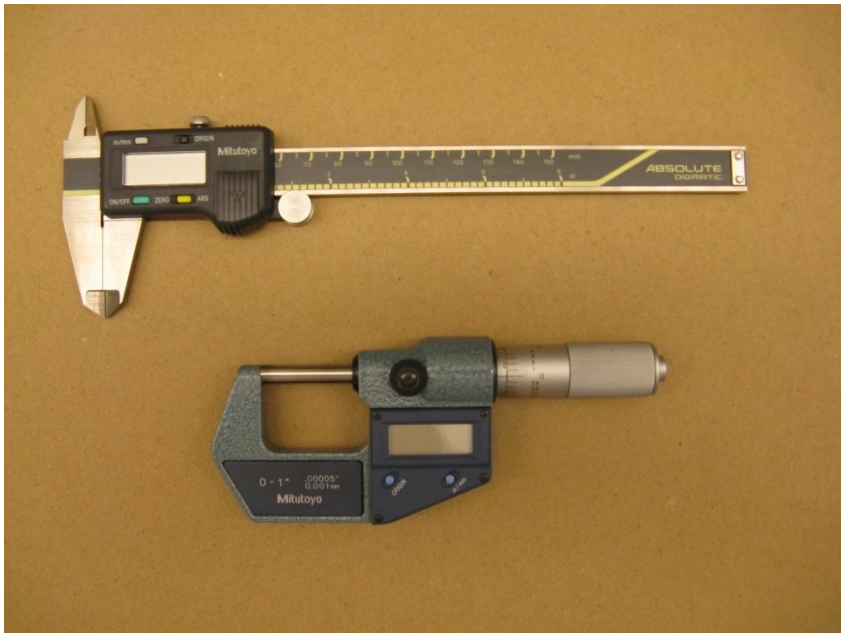
Tape Width

Rolls produced in a large sheet (called a “jumbo roll”) are slit into individual rolls. Detectable differences in width among rolls of tape produced in the same batch are possible.



Thickness: Overall and Backing

The overall thickness of the tape and/or the thickness of the backing alone can vary greatly from sample to sample depending on the quality of the tape and the intended use.

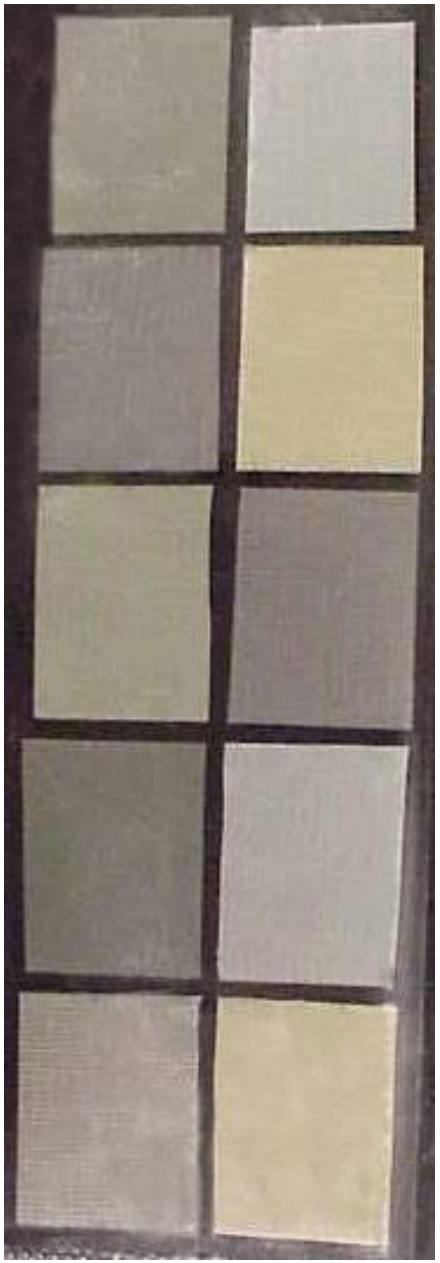


Examples of tools used in tape thickness measurements.

Adhesive: Color

Adhesive colors can include:

- Colorless
- White
- Off-white
- Tan
- Gray
- Brown
- Black



Duct Tapes

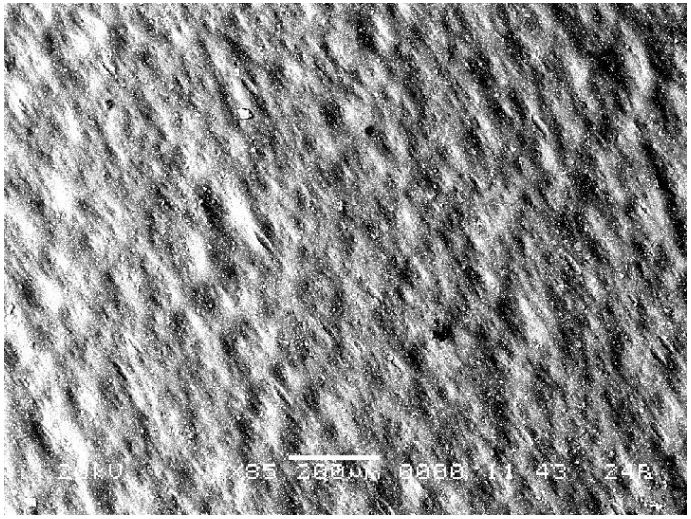
Backing: Color

Backing

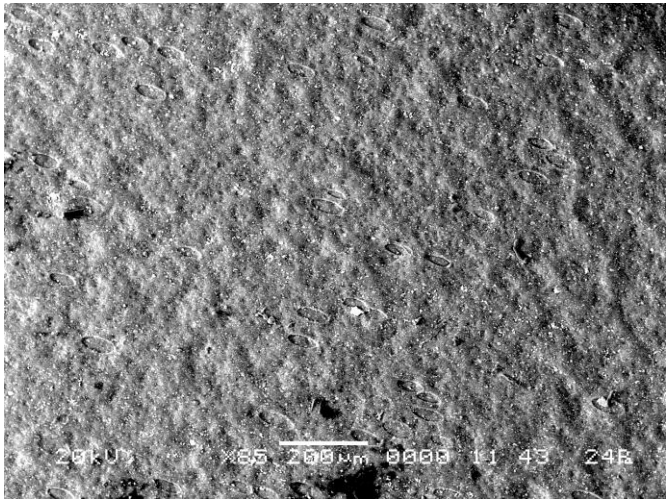
- Duct tapes are usually gray, but can vary in color.
- Electrical tapes are usually black, but can vary in color.
- Packaging tapes are usually colorless or tan.

Duct Tapes

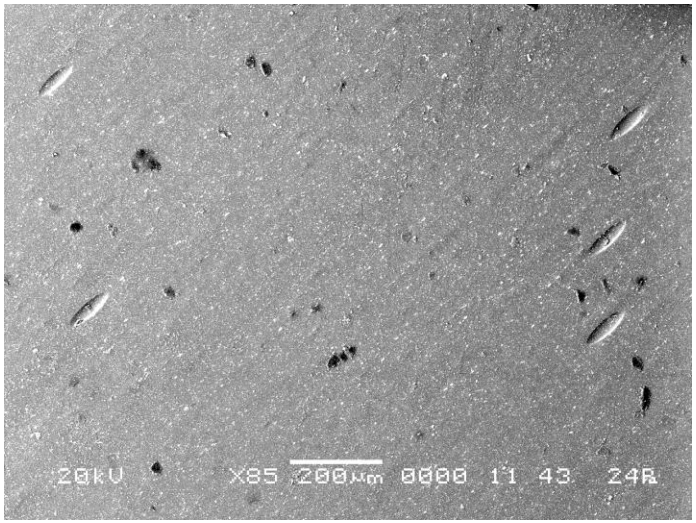
Backing: Surface Characteristics



Manco



Shurtape

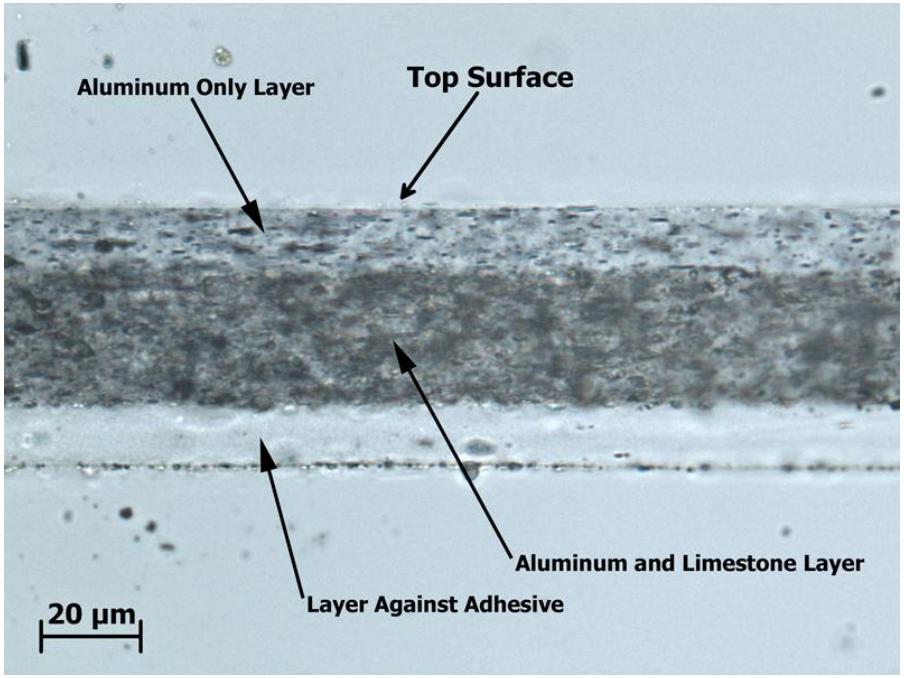


Vanguard

Electron-micrographs of electrical tape backings

Backing: Layer structure

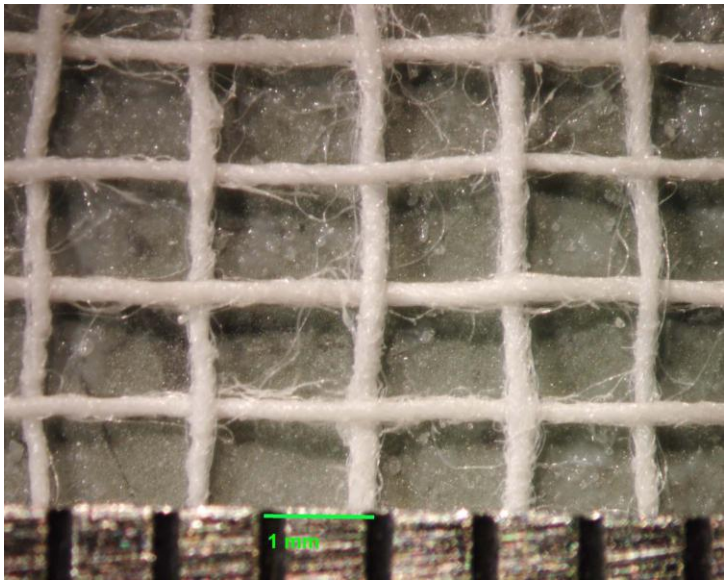
- Tape backing may have multiple layers.
- These layers should be characterized and then analyzed with appropriate analytical instrumentation.

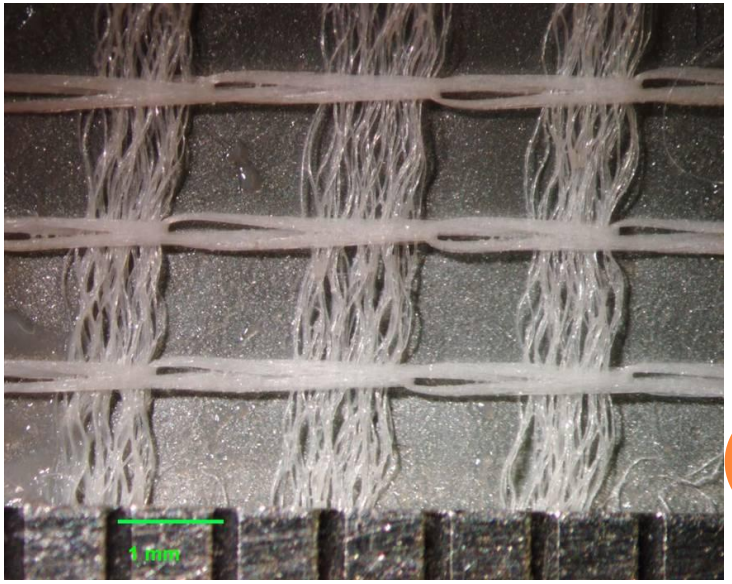


Cross-section of duct tape backing

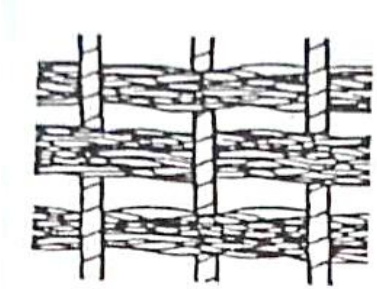
Scrim

- Scrim is fabric reinforcement that imparts strength to duct tape.
- The scrim is woven or knitted and is usually composed of cotton, polyester or a combination of the two fiber types.
- Scrim can have highly variable construction among manufacturers of duct tape.

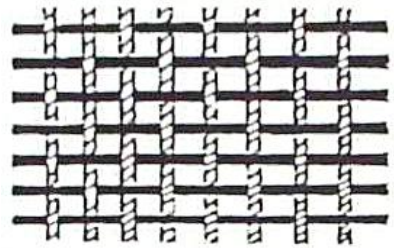




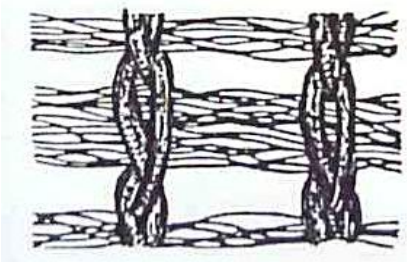
SCRIM: FABRIC CONSTRUCTION



Plain weave with texturized fill yarns



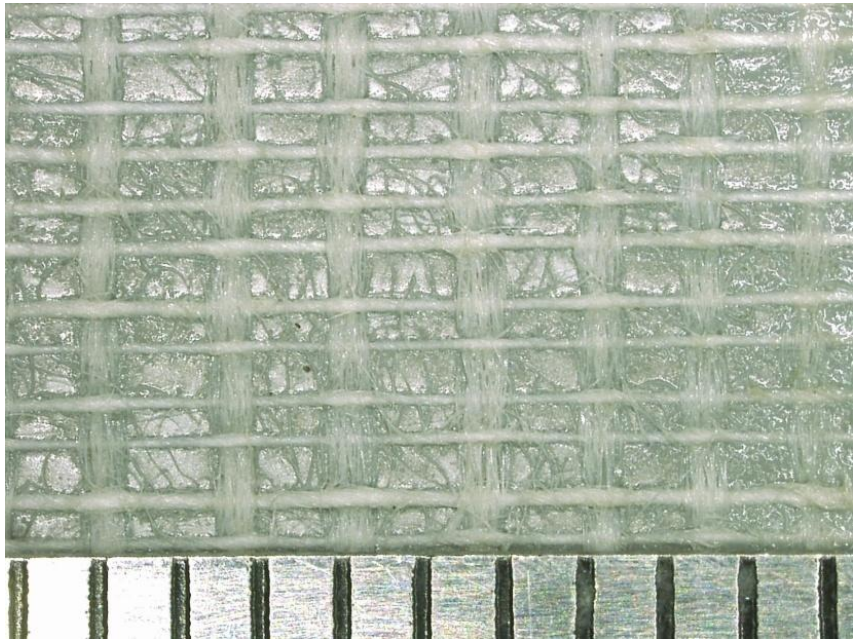
Plain weave with straight loose or bundled fill yarns



Weft insertion with texturized fill yarns

Scrim: Yarn Count

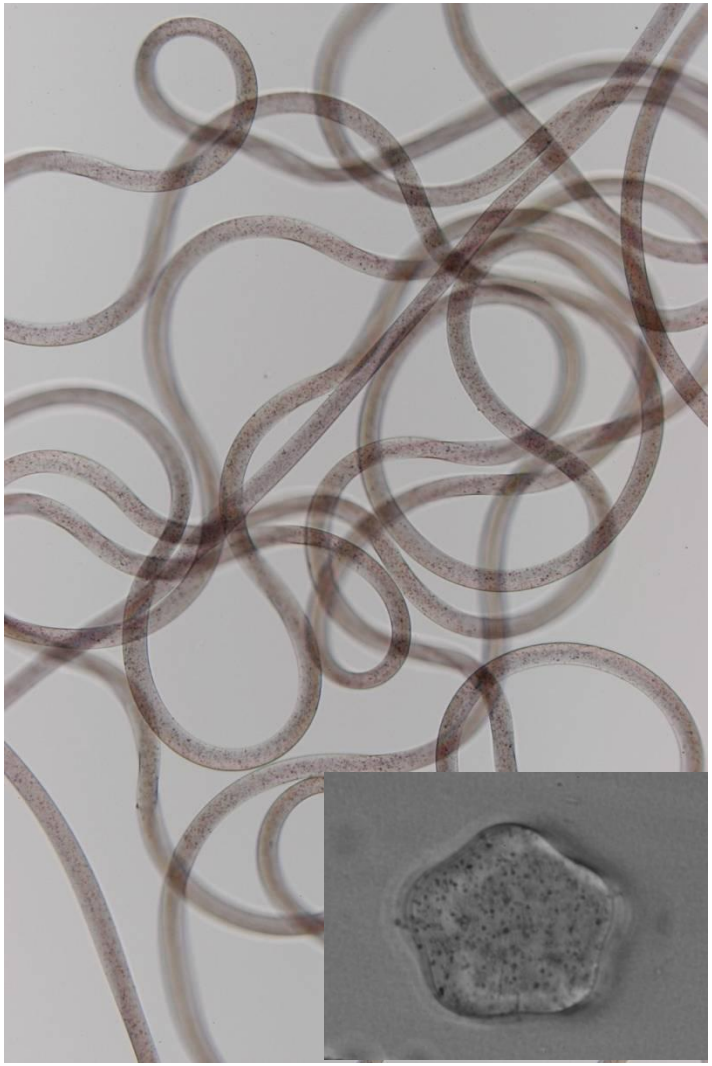
Yarns per inch can vary among duct tape in the warp (machine direction) and in the weft (fill or cross direction).



After removal of the adhesive, the scrim can be examined.

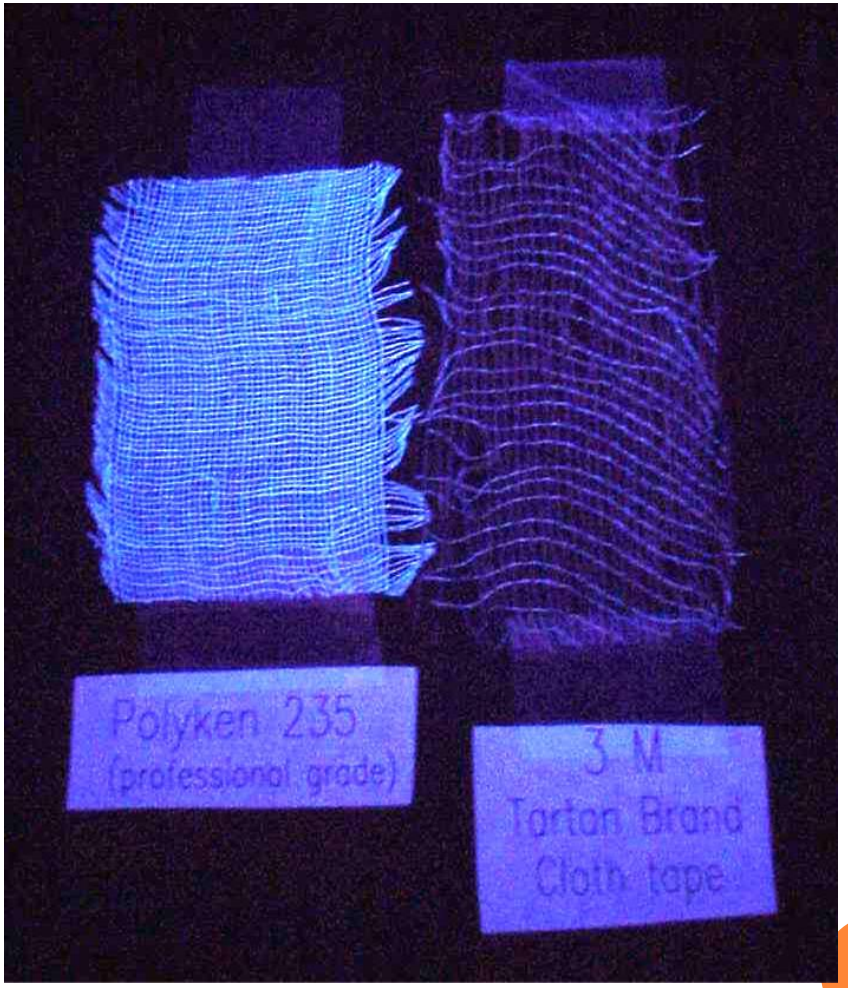
Scrim: Fiber Examinations

- Identification and comparison of the scrim fibers can be achieved using the following instruments:
  - PLM
  - Comparison microscope
  - Fluorescence microscope
  - FTIR
- Refer to the *Forensic Fiber Examination Guidelines* at SWGMAT.org



SCRIM: FLUORESCENCE

- Optical brighteners may be present on the yarns that compose the scrim fabric.
- The optical brighteners will cause the scrim yarns to fluoresce.
- The scrim may be examined using short and long wavelength illumination.

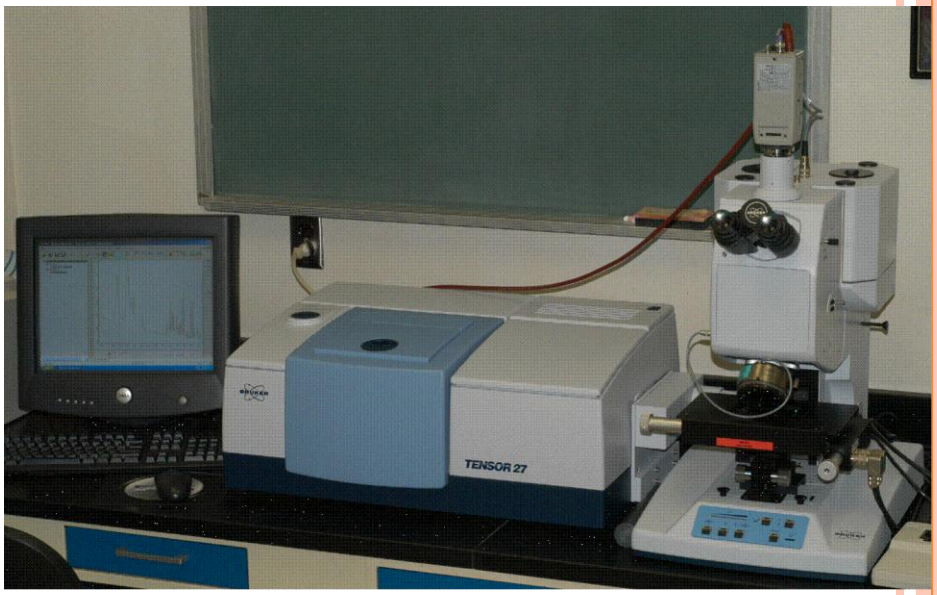


Light Microscopy

- Light microscopy offers a simple way to assess the similarities and differences between tape components such as:
  - -Filler
  - -Film orientation
  - -Layer structure
- The PLM is used in the analysis of the fibers making up the scrim fabric or other reinforcement used in tape construction.
- Refer to the *Guideline for Using Light Microscopy in Forensic Examination of Tape Components* at SWGMAT.org.

Fourier Transform Infrared Spectroscopy (FTIR)

- FTIR is an instrumental method that uses infra-red light to identify the chemical components of various materials used in pressure sensitive tapes.
- Refer to the *Guideline for Using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations* at SWGMAT.org.



FTIR Examination of Tapes

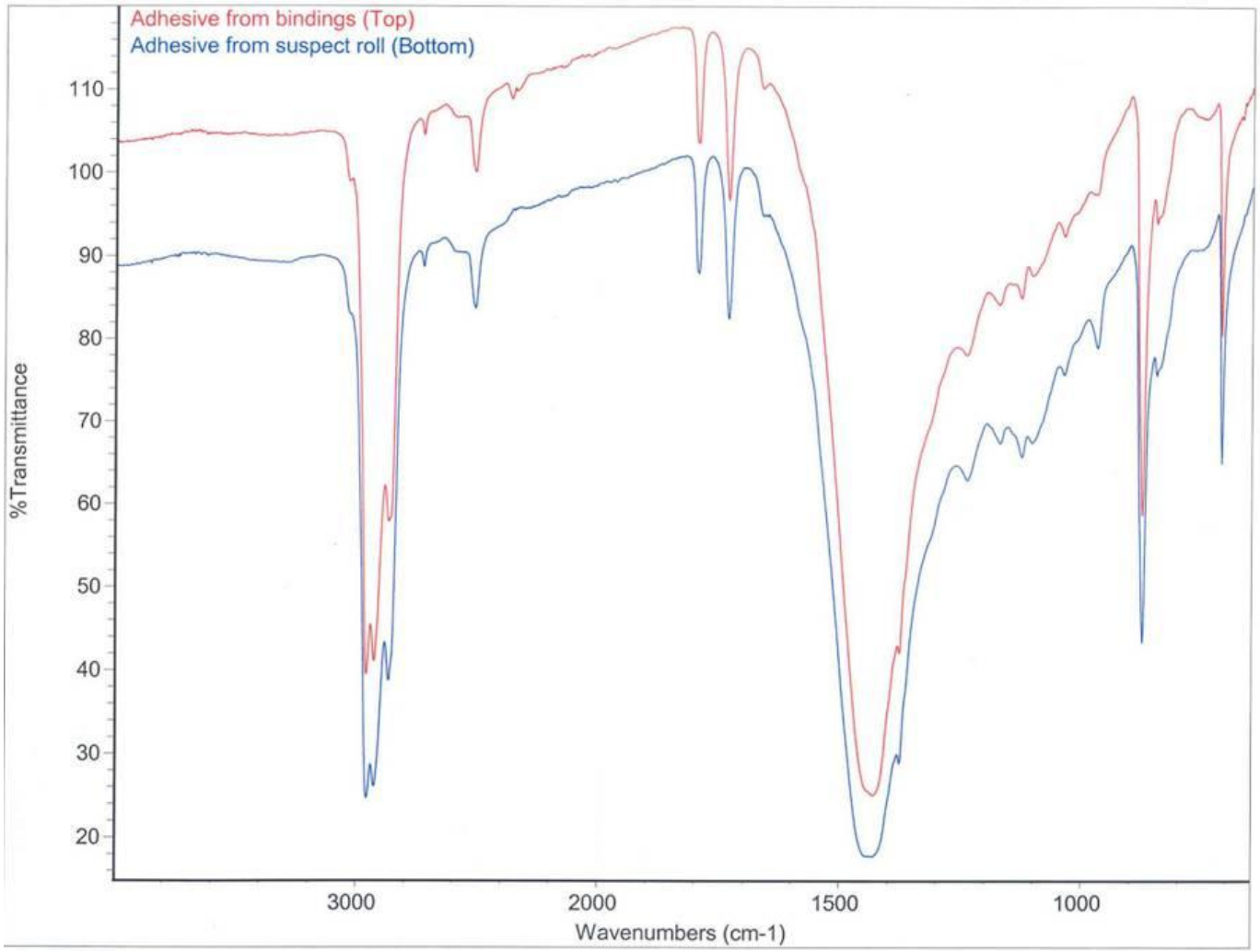
FTIR can elucidate the chemical components of each part of the tape. It is useful in determining:

- Composition of the backing layers.
- Composition of the components of the adhesive such as the elastomers (which provides viscoelasticity to the adhesive) and tackifyers (which provides tack to the adhesive).
- Additives that add volume, color or special properties to the finished tape.
- Fiber type (along with the PLM) in tapes that contain fabric.

The spectral data generated by the FTIR is also used for comparisons among tape samples and for comparison to various manufacturers' data in an attempt to source the tape.

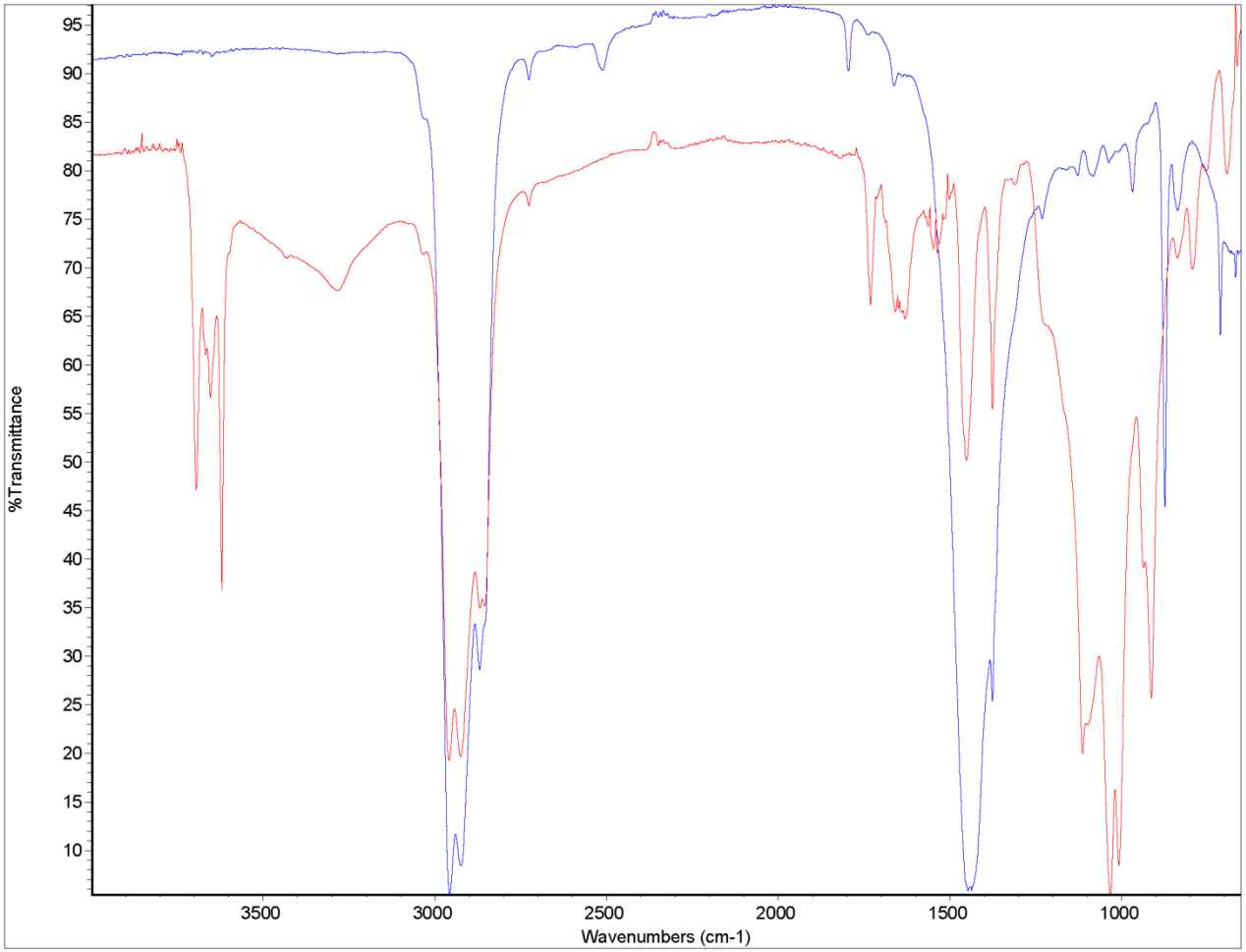
FTIR: SPECTRAL COMPARISON

Indistinguishable Duct Tape Adhesives



FTIR: SPECTRAL COMPARISON

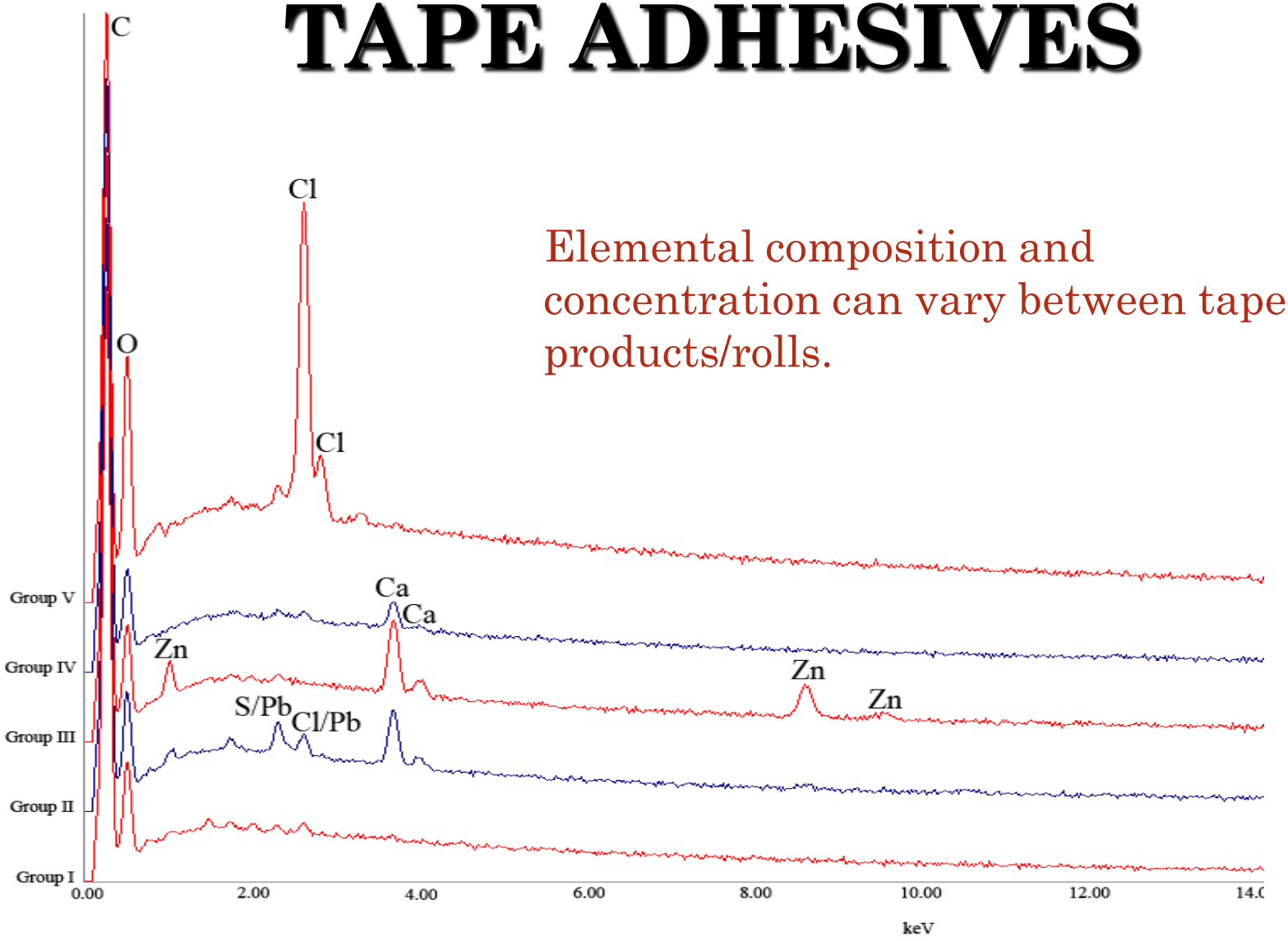
Differing Duct Tape Adhesives



Elemental Analysis

- Elemental analysis identifies the element composition of the tape components
- The following include (but are not limited to) the techniques that may be used for the elemental analysis:
  - Scanning electron microscopy-energy dispersion spectroscopy (SEM-EDS)
    - Refer to the *Guideline for Using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy in Forensic Tape Examinations* at SWGMAT.org.
  - X-ray Fluorescence (XRF)

SEM-EDS OF ELECTRICAL TAPE ADHESIVES

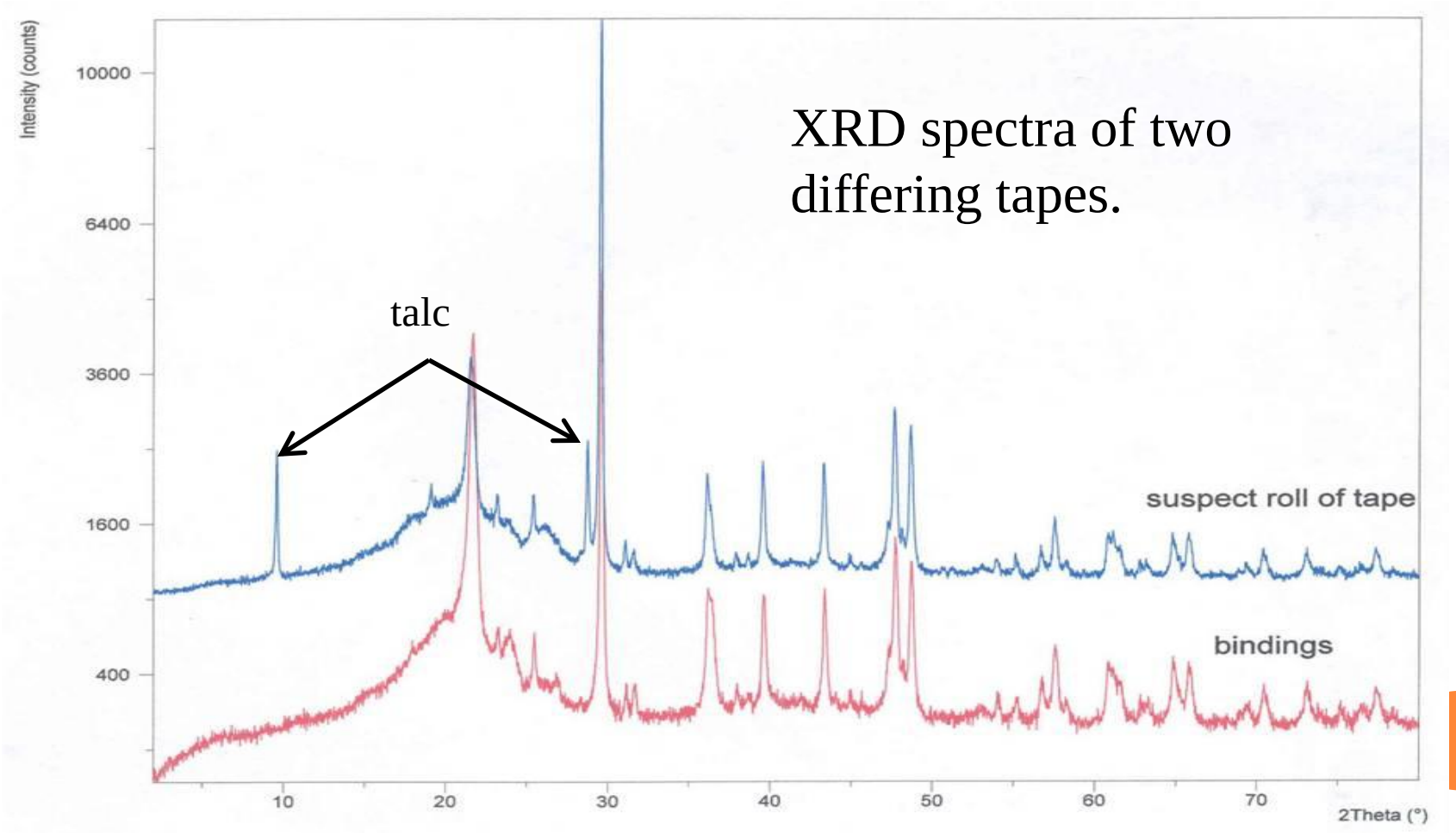


Elemental composition and concentration can vary between tape products/rolls.

X-RAY DIFFRACTION

- X-ray diffraction is used to identify components of tape by their crystal structure.
- The X-ray beam is used to strike the crystals (in the tape specimen) and the beam will be scattered in a predictable way for that particular substance.
- This information is then used to identify the crystalline or polymorphic form of the various components, such as distinguishing the rutile and anatase forms of titanium dioxide.

XRD ANALYSIS OF DUCT TAPE ADHESIVES

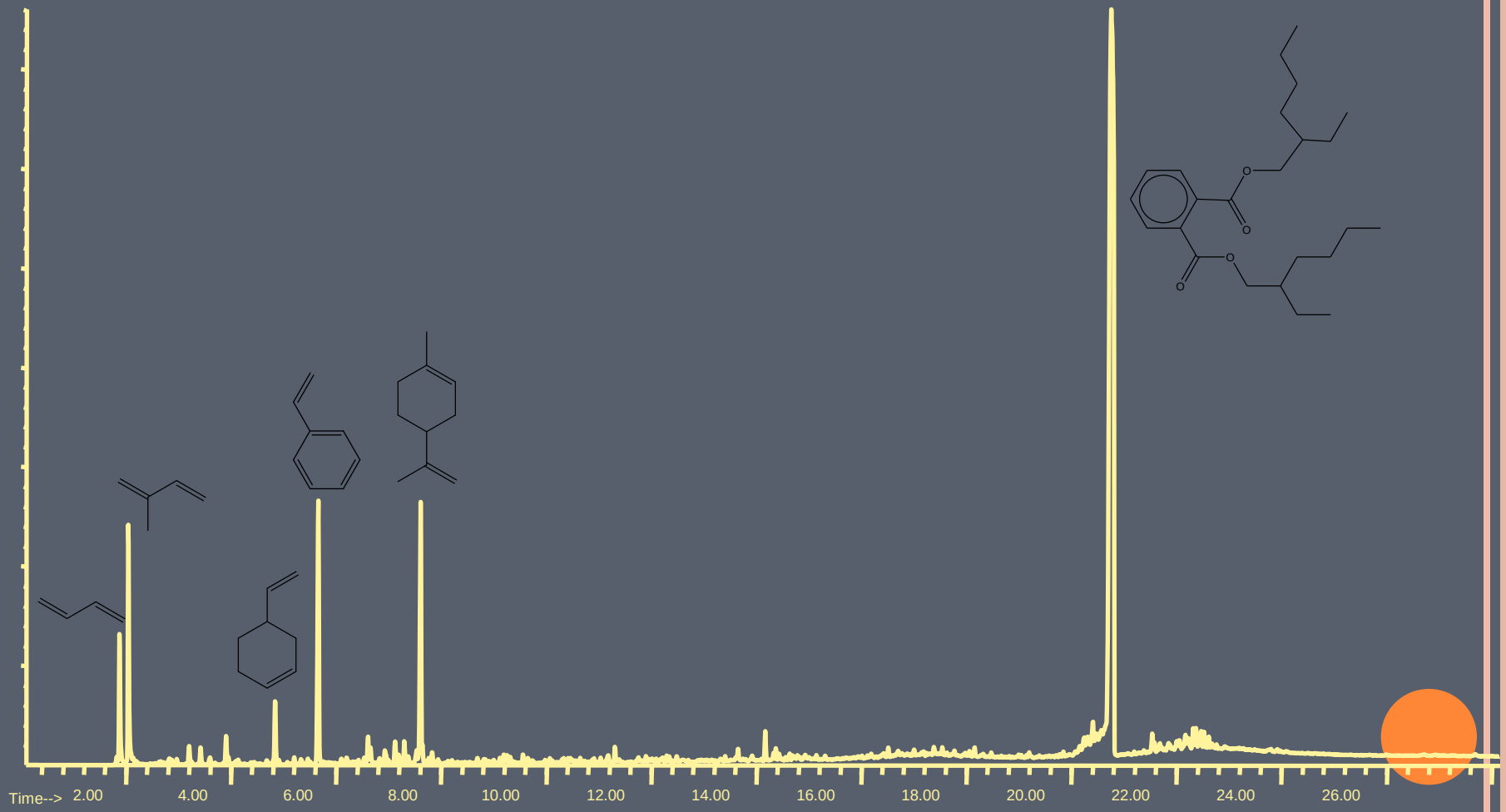


XRD spectra of two differing tapes.

PYROLYSIS – GAS CHROMATOGRAPHY (Py-GC)

- Pyrolysis gas chromatography can be used to differentiate organic constituents.
- Pyrolysis is the thermal decomposition of large complex molecules into smaller fragments, which are then separated by gas chromatography.
- A mass spectrometer (MS) may be used as a detector to assist the analyst in identifying the individual fragments.

PY-GCMS-TOTAL ION CHROMATOGRAPH OF DUCT TAPE ADHESIVE



Possible Conclusions for Tape Examination and Comparison

- A physical match was made between the unknown tape and the known tape; therefore, the unknown tape and the known tape were once one continuous piece.
- Unknown tape(s) exhibit the same physical characteristics and chemical and elemental composition to the known tape; therefore, it could have originated from the known tape.
- Unknown tape(s) is dissimilar to the known tape; therefore, it could not have originated from the known tape.
- Examination of the submitted tape showed it to be consistent in physical characteristics, chemical composition and elemental composition to tape manufactured by *Company Name*®.

THE DAUBERT STANDARD CRITERIA FOR ADMISSIBILITY

Meeting the Daubert Criteria

1. Has the theory or technique been tested using the scientific method?
2. Has the technique/methodology been subject to peer review/publication?
3. What is the error rate if it can be calculated?
4. Are there standards controlling the technique's operation and are they maintained?
5. Is there general acceptance within the relevant scientific community?

Testability: Inter-tape Variability

Different rolls of the same class of tape can vary in physical construction and in chemical composition. Supporting literature for this theory can be found in the following publications:

- Johnston J and Serra J. The examination of pressure sensitive adhesive tapes. *IAMA Newsletter*, May 2005, 5(1):19-31.
- Smith J. The forensic value of duct tape comparisons. *Midwestern Association of Forensic Scientists, Inc. News Letter*, January 1998, 27(1):28-33.
- Benson JD. Forensic examination of duct tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. FBI Academy, Quantico, VA, July 31-August 2, 1984: 145-6.
- Snodgrass H. Duct tape analysis as trace evidence. *Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence*, FBI Academy, Quantico, VA, June 24-28, 1991: 69-73.
- Kee Thomas G. The characterization of PVC adhesive tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. Quantico, VA July 31 – August 2, 1984, 77 – 85.
- Keto RO. Forensic characterization of black polyvinyl chloride electrical tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. Quantico, VA July 31 – August 2, 1984 Bureau of Alcohol, Tobacco and Firearms. Rockville, Maryland, 137 – 143.

TESTABILITY: INTER-TAPE VARIABILITY (CON'T)

- Goodpaster JV, Sturdevant AB, Andrews KL, Brun-Conti L. Identification and comparison of electrical tapes using instrumental and statistical techniques: I. Microscopic surface texture and elemental composition. *Journal of Forensic Sciences*; 2007; 52:610-29.
- Goodpaster JV, Sturdevant AB, Andrews KL, Briley EM, Brun-Conti L. Identification and comparison of electrical tapes using instrumental and statistical techniques: II. Organic composition of the tape backing and adhesive. *Journal of Forensic Sciences*; 2009; 54:328-38.
- Hobbs A, Gauntt J, Keagy R, Lowe P, and Ward D. New approach for the analysis of duct tape backings, *Forensic Science Communications*, January 2007.
- Mehltretter AH, Bradley MJ, and Wright DM. Analysis and discrimination of electrical tapes: Part I. Adhesives, *Journal of Forensic Sciences*, 2011, 56(1): 82-94.
- Mehltretter AH, Bradley MJ, and Wright DM. Analysis and discrimination of electrical tapes: Part II. Backings, *Journal of Forensic Sciences*, JFS, 2011, 56(6); 1493-1504.

Testability: Intra-tape consistency

The physical and chemical characteristics are consistent throughout the roll of tape. Supporting literature for this includes:

- Blackledge RD. Tapes with adhesive backings: their characterization in the forensic science laboratory. *Appl Polym Anal Charact* 1987, 413-421.
- Merrill R, Bartick E. Analysis of pressure sensitive adhesive tape: 1. evaluation of infrared ATR accessory advances. *Journal of Forensic Sciences;* 45:1 (2000), 93-98.
- Jenkins, Jr. TL. Elemental examination of silver duct tape using energy dispersive X-ray spectrometry. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. FBI Academy, Quantico, VA, July 31-August 2, 1984: 147-9.
- Keto RO. Forensic characterization of black polyvinyl chloride electrical tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. Quantico, VA July 31 – August 2, 1984 Bureau of Alcohol, Tobacco and Firearms. Rockville, Maryland, 137 – 143.

TESTABILITY: ANALYTICAL SCHEME

Numerous articles have been published the combination of techniques used in the analysis of tapes

- Snodgrass H. Duct tape analysis as trace evidence. *Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence*, FBI Academy, Quantico, VA, June 24-28, 1991: 69-73.
- Sakayanagi M, et al. Identification of pressure-sensitive adhesive polypropylene tape. *Journal of Forensic Sciences*; 48 (1) 2003.
- Keto RO. Forensic characterization of black polyvinyl chloride electrical Tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. Quantico, VA July 31 – August 2, 1984 Bureau of Alchohol, Tobacco and Firearms. Rockville, Maryland, 137 – 143.
- Hobbs AL, Gauntt JM, Keagy RL, Lowe PC, Ward DC. A new approach for the analysis of duct tape backings. *Forensic Science Communications;* 9 (1), 2007.
- Maynard P, Gates K, Roux C, Lennard C, "Adhesive Tape Analysis: Establishing the Evidential Value of Specific Techniques," *J. For. Sci.*, 46, 2001, 280-287.

TESTABILITY: TECHNIQUES

Numerous articles have been published on the techniques used specifically for forensic tape comparisons:

- Bradley MJ, Keagy RL, Lowe PC, Rickenback MP, Wright DM, LeBeau MA. A validation study for duct tape end matches. *Journal of Forensic Sciences*; 51, 2006, 504 – 508.
- Randle WA. Microscopical Examination of duct tape adhesive fillers. *Presented at INTER/MICRO*; June 2004, Chicago, IL.
- Smith J, Weaver R. PLM examinations of clear polymer films. *The Microscop;*, 52, 2004, 113-118.
- Rappe R. Measurement of principal refractive indices of oriented polymer films. *The Microscope;* 35 (1987), 67-82.
- Williams ER, Munson TO. The comparison of black polyvinylchloride (PVC) tapes by pyrolysis gas chromatography. *Journal of Forensic Sciences*; 33:5 (1988), 1163-70.
- Merrill R and Bartick E. Advances of infrared ATR analysis of duct tape. *Presented as a poster at the 51st AAFS meeting in Orlando, FL*; Feb 15-20, 1999.

TESTABILITY: TECHNIQUES (CON'T)

- Blackledge RD. Comparison of masking tapes by fluorescence spectroscopy. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*. FBI Academy, Quantico, VA. July 31-Aug 2, 1984, pp. 135.
- Dobney AM, Wiarda W, de Joode P, and van der Peijl G. Sector field ICP-MS applied to the forensic analysis of commercially available adhesive packaging tapes. *Journal of Analytical Atomic Spectroscopy;*,17, 2002, pp. 478-484.
- Bradley MJ, Gauntt JM, Mehltretter AH, Lowe, P.C., and Wright, D.M., "A Validation Study for Vinyl Electrical Tape End Matches," *J. For. Sci.,* 56, 2011, pp. 606 - 611.

PEER REVIEW

Scientific papers on tape are peer reviewed and can be found in the following journals as exemplified in the previous slides:

- *Forensic Science Communications*
- *Journal of Forensic Sciences*
- *American Society of Trace Evidence Examiners (ASTEE) Journal*
- *Association of Firearms and Toolmark Examiners (AFTE) Journal*
- *Journal of Analytical & Applied Pyrolysis*
- *Journal of Analytical Atomic Spectroscopy*
- *Journal of Polymer Science*
- *The Microscope (editor reviewed)*

Error Rate

- Two sources of potential error during the analysis of tape are the examiner and the instrumentation.
- There are quality assurance measures in place to ensure that the examiner is well trained, proficiency tested and their work is reviewed.
- There are standard operating procedures in place to ensure that the instrument is operating properly and used correctly.
- None of the potentials of error can be accurately determined or quantified for a specific examination, examiner, or case.

Error Rate

- Measures taken to ensure against errors by the examiner:
  - The examiner meets the educational requirements for the position.
  - The examiner received the job specific training for the analysis and comparisons of tape.
  - The examiner successfully completed the competency testing before starting tape examinations.
  - The examiner successfully completes ongoing proficiency testing.
  - The examiner works in an accredited laboratory, which ensures good scientific practices through a quality control/quality assurance program.
  - Every case is subjected to peer/technical and administrative review.

Error Rate

- Measures taken to ensure against errors by the instrumentation :
  - The instruments are validated or function verified at regular intervals.
  - The instruments are operated by a trained examiner.
  - The proper instrument is used to glean information appropriate for the examination following laboratory procedure.

Standards Controlling the Techniques

- Forensic scientists address tape examinations in formal working groups:
  - Scientific Working Group for Materials Analysis (SWGMAT) – Tape Subgroup
    - Guideline for Assessing Physical Characteristics in Forensic Tape Examinations
    - Guideline for Using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations
    - Guideline for Using Light Microscopy in Forensic Examinations of Tape Components
    - Guideline for the Forensic Examination for Pressure-Sensitive Tape
    - Guideline for Using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy in Forensic Tape Examinations
  - European Paint & Glass Working Group (EPGWG)

Standards Controlling the Techniques

- Laboratory Examination Guidelines: each laboratory should have a tape examination procedure with their protocols or standard operating procedures manual.
- American Society for Testing and Materials (ASTM)
  - Guidelines for the techniques of analysis such as microscopy, PLM, FTIR, SEM/EDS, XRD, and PyGC including general use techniques.
  - Guidelines for adhesives, fibers, fabric, plastics, and rubber.
  - Manufacturing guidelines, specifically on the testing methods and specifications for pressure sensitive tapes.

General Acceptance

- Federal, state and local/city laboratories, as well as international laboratories conduct forensic tape examinations.
- In 2000, surveys were mailed to ASCLD/LAB accredited crime labs. Eighty-seven of the 116 laboratories that responded indicated that they perform forensic tape examinations. This demonstrates that tape examinations are commonly performed in forensic laboratories.
- Analysis of tape is not unique to forensic science. Industry is also interested in being able to characterize tape.

General Acceptance: Manufacturing Community

Scientific information on pressure sensitive tape from the tape manufacturing community

- *Pressure Sensitive Tape Council (PSTC) at www.PSTC.org*
- *Books*
  - Satas D, editor. *Handbook of Pressure Sensitive Adhesive Technology*, VanNostrand Reinhold, New York, 1989.
  - Johnston J. *Pressure Sensitive Adhesive Tape*. Pressure Sensitive Tape Council, Northbrook, IL, 2003.

General Acceptance: Forensic community

- The forensic comparison of tape is generally accepted. It is based on research in the previously described in peer reviewed journals and in forensic text books. The following SWGMAT documents were produced by forensic tape examiners. They incorporate the research based on the aforementioned literature:

  - *Guideline for the Forensic Examination of Pressure-Sensitive Tapes*
  - *Guideline for assessing Physical Characteristics in Forensic Tape Examinations*
  - *Guideline for using Light Microscopy in Forensic Examinations of Tape Components*
  - *Guideline for using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations*
  - *Guideline for using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy in Forensic Tape Examinations*

General Acceptance: instrumentation and analytical methods

- The instrumentation and analytical methods used in the analysis and comparison of tape have been utilized by the scientific community for many years.
- Complementary techniques are chosen to provide additional information regarding sample composition.
- The combination of techniques is chosen to achieve the maximum potential for sample discrimination.

Court Decision: U.S. v. Rice

United States District Court – Western District of Virginia
Charlottesville Division

United States of America v. Darrell David Rice

Case No. 3:02 CR 00026

Judge Norman K. Moon

Duct Tape Fracture Match - Memorandum Opinion

"…the Daubert factors did not appear to be in question."

" The Court will not exclude [the] duct tape reconstruction testimony because the Government has proven that it is scientifically reliable under Daubert."

COURT DECISION: KY V. SCHERRETZ

Commonwealth of Kentucky – Henderson Circuit Court
Commonwealth of Kentucky v. Jeffrey A. Scherretz
Indictment No. 06-CR-00195

Duct Tape Fracture Match - Opinion

"…the method of fracture matching used to analyze duct tape…is generally reliable… this method has been generally accepted in the scientific community. It has been subjected to peer review and publication… The method can and has been tested for its reliability."

" The Court believes that [the] testimony should not be excluded."

Court Decision: NH v. Moulton

State of New Hampshire-State Superior Court

State of New Hampshire v. Richard Moulton

Docket # 2011-CR-041

Duct Tape Fracture Match - Opinion

"…the offered scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or determine a fact in issue, that the offered testimony is based upon sufficient facts or data, is the product of reliable principles and methods, and based upon a reliable application of the principles and methods to the facts of the case…"

Conclusions

- Pressure sensitive tape is recognized and acknowledged as a valuable type of physical evidence within the forensic science community.
- The forensic examination and comparison of tape successfully meets the five factors considered by the Daubert inquiry to determine the validity, reliability and admissibility of the scientific expert testimony.
- Previous court rulings have held that experts' testimony would not be excluded on the basis of a Daubert challenge specifically related to pressure sensitive tape cases.