Admissibility Package for Tape all Wrapped Up

Mark A. Ahonen

Presentation Objectives

- PowerPoint presentation to educate appropriate personnel
- Current status of SWGMAT tape documents
- Admissibility package for court purposes
  - Tape bibliography, tape survey, sourcing bibliography with comments

Presentation Disclaimers

- The admissibility package presentation today will not be given the same way I would deliver it in a court proceeding
  - Take out the first four slides
  - Many of the slides will not be discussed in detail
- Some of the ideas and topics of the presentation were taken from others

Presentation Notes

- An attempt was made to have a ‘generic’ admissibility package presentation that would be fairly applicable to all laboratories
- Common sense slides will be discussed briefly to help with purpose
- A modification would be needed for:
  - Laboratories with a completely different analysis scheme
  - If sourcing is the main emphasis

Admissibility Package - Tape

Pressure Sensitive Tape as Physical Evidence

- Associating one person, place, or thing with another person place or thing (i.e. common origin)
- Verifying a story or as an investigative lead. (i.e. sequencing, sourcing)

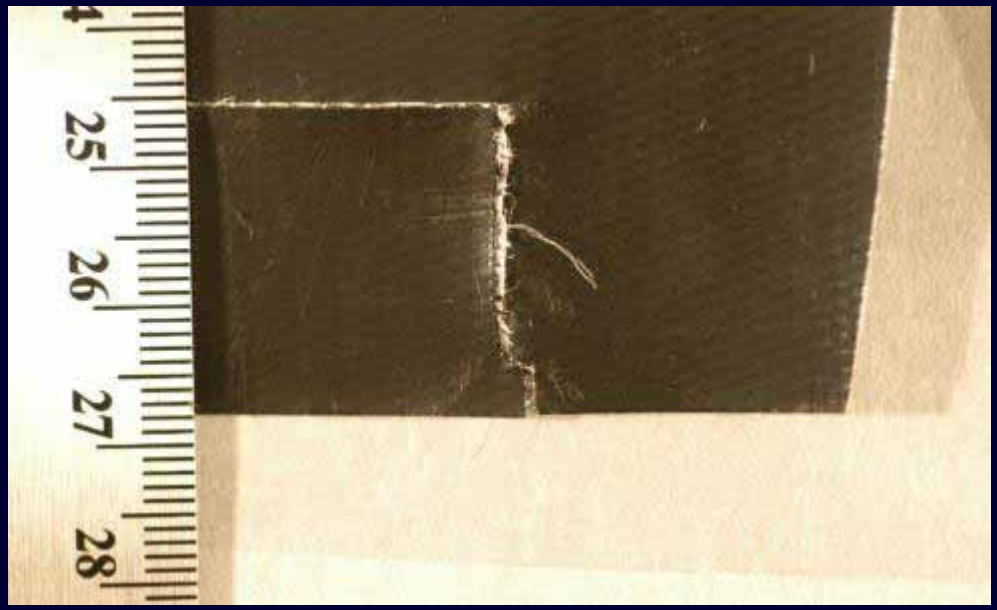
Tape – Associative Evidence

- Involves the comparison of samples to determine if they could share a common origin
- The goal is to determine if any significant differences exist

Tape - Definitive Association

An end match provides a definitive association to an individual source

A physical end match is the most compelling type of association between two tapes and should always be evaluated.



Sequencing

- End matching pieces of tape can tell the sequence of events in the use of that particular roll (e.g. legs taped first, then arms)
- If tape is cut – the multiple pieces of duct tape can still be attempted to be sequenced

Sourcing

- An attempt to identify possible product information, manufacturing, and retailing sources can 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.

Forensic Examination of Tapes

Guideline for the Forensic Examination of Pressure-Sensitive Tapes – Forensic Science Communications

October 2008, Vol. 10 – Number 4

http://www.fbi.gov/hq/lab/fsc/backissu/Oct2008/index.htm

Common types of tape

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

Tape Variability

Some classes of tape are more variable than others. Typically, if the tape is more complex, it will have more variability and the weight of the association will be stronger.

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

Tape Conclusions

- The two tapes possess a physical end match, therefore the pieces of tape were once connected to and part of the same piece
- Questioned tape(s) exhibit the same characteristics and chemistry to the known sample, therefore are consistent with having come from the known source (roll)
- Questioned tape(s) is dissimilar to the known sample ,therefore it could not have originated from the known sample (roll)

Examination of Tape Considerations

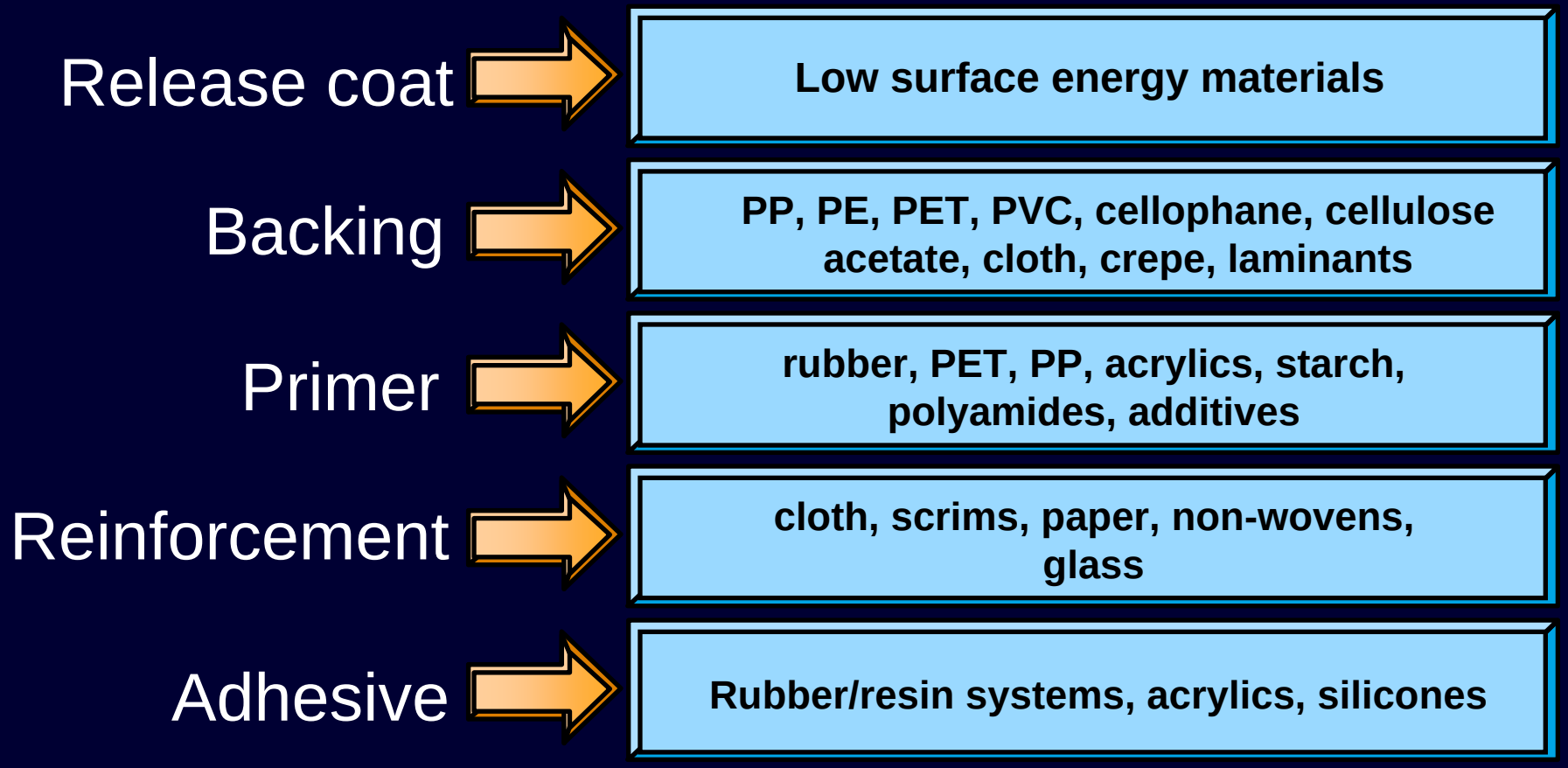
- Extraneous material collection and preservation
- The order of examinations conducted on the tape
- Technique used to untangle the tape

Locard's Exchange Principle

Exchange Principle

- When two people or a person and an object come into contact, there is an exchange of material that occurs.
- The adhesive tape layer collects many different types of physical evidence and can be a great source of transferred material
- Trace evidence can be removed from the tape by examining it under low magnification and “picking” off with tweezers

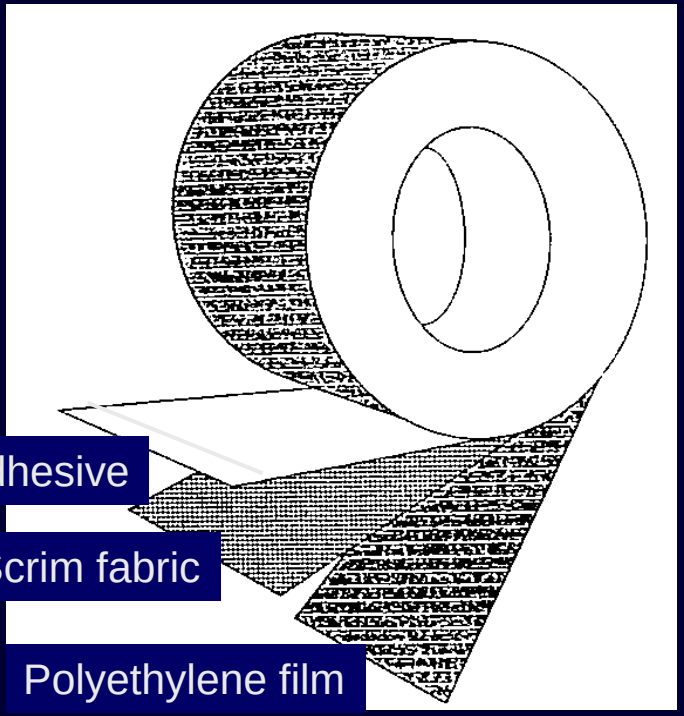
Tape Construction



*Not all tapes contain all of the listed tape layers

Techniques of Tape Analysis

- Physical match
- Physical characteristics
- PLM
- FTIR
- Elemental analysis
- Pyrolysis-GC/MS
- Fluorescence



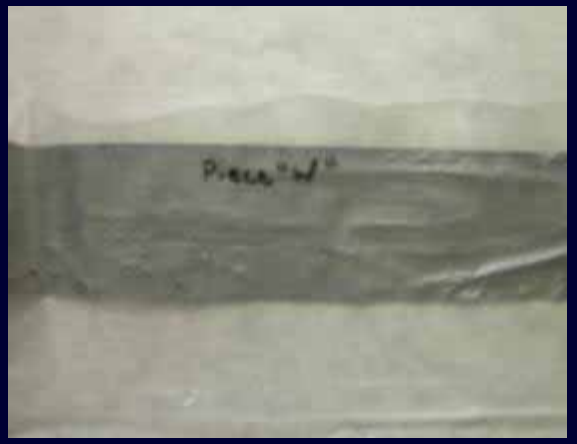
Physical Characteristics

Guideline for Assessing Physical Characteristics in Forensic Tape Examinations – Forensic Science Communications (April 2010)

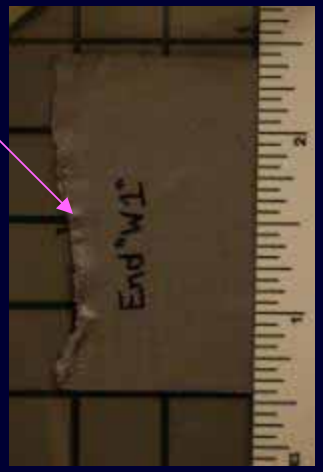
- A stereomicroscope can be used to evaluate the possibility of a physical end match. If the tape contains fabric re-enforcement, it should be evaluated in determining if a physical end match exists. The physical end match should be documented .

Matching Items, Piece X to Piece W

PIECE X



PIECE W



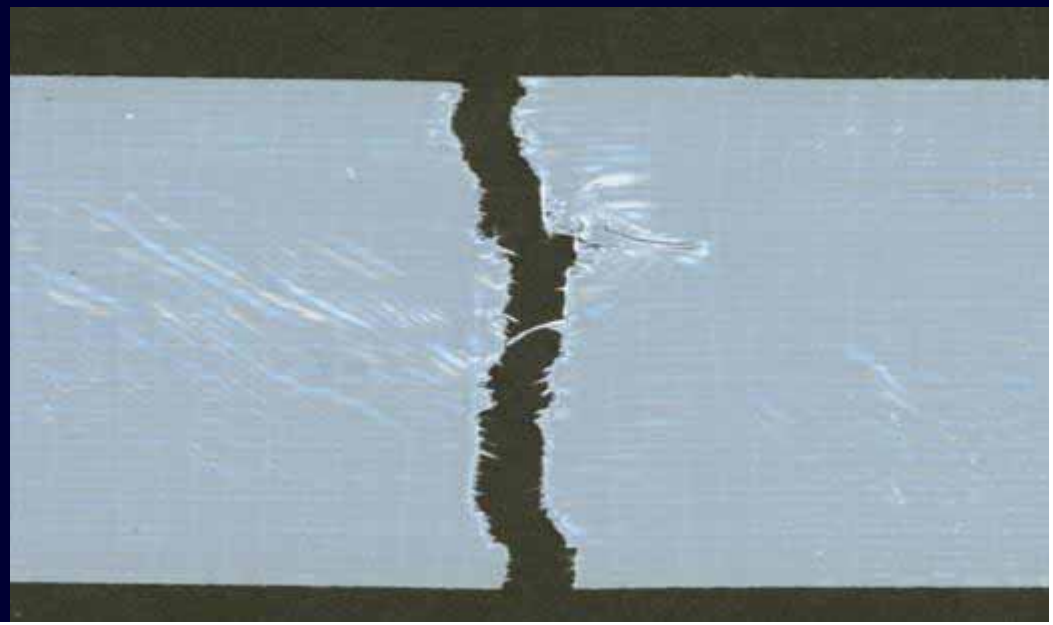
END OF PIECE X

BEGINNING OF PIECE W

RESULTING MATCH

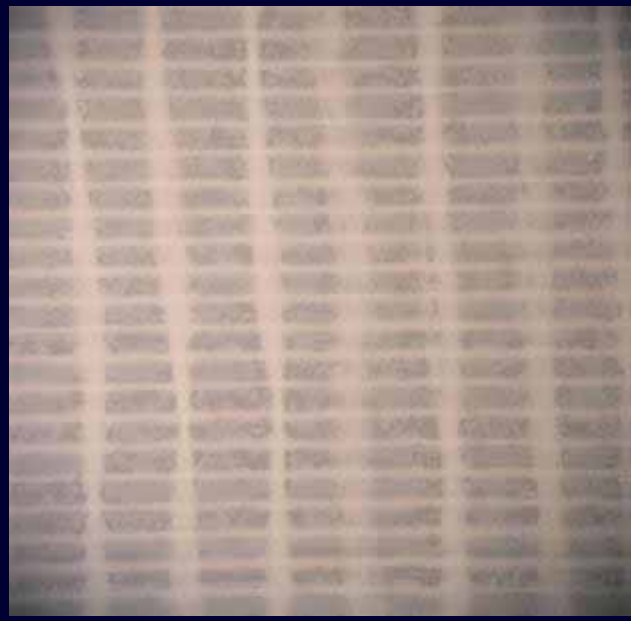
Physical End Matching

- The backing of tapes are pliable, therefore, the fractured edge is often distorted.
- Physical characteristic and chemical composition assessment of the tapes may aid in the association



Physical Characteristics

- Tape Width
- Tape Thickness
- Backing Color
- Adhesive Color
- Scrim – Yarn Construction
- Scrim – Yarn Counts
- Scrim – Yarn Twist
- Scrim – Fiber Examination
- Backing – Surface Characteristics
- Backing – Thickness
- Backing X-section



Duct Tape Backing - Color

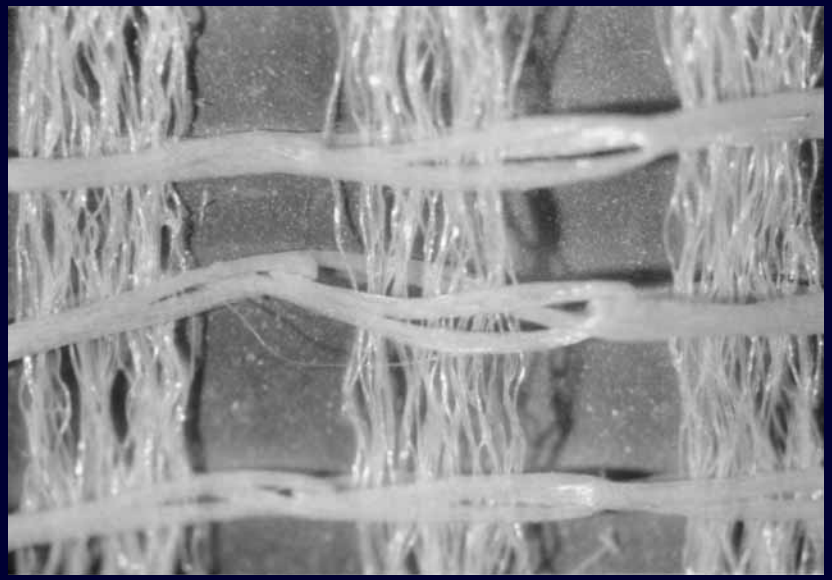
- Backings - are usually gray, but can vary in colors

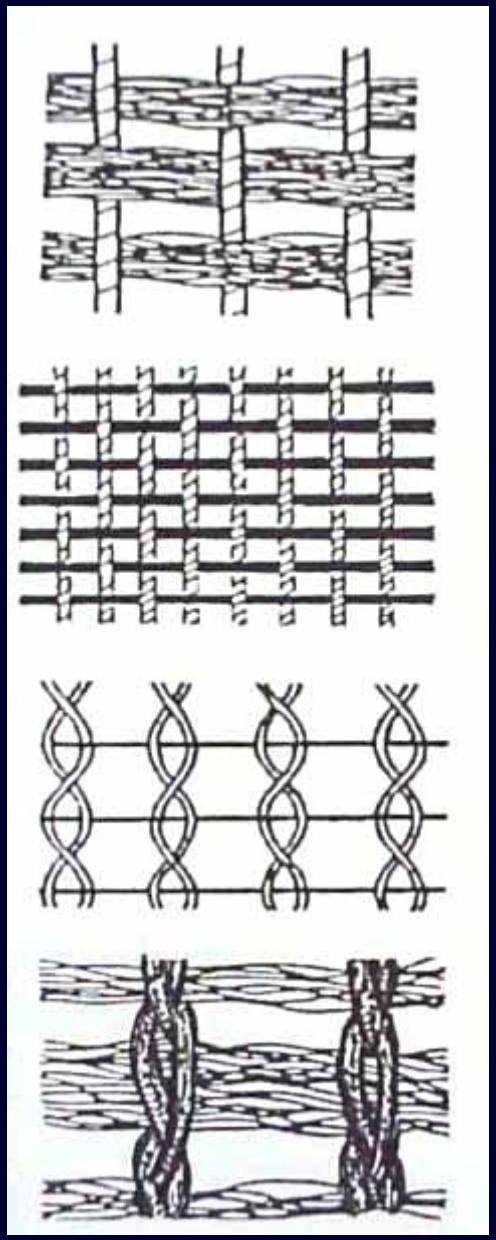
Pressure Sensitive Adhesives - Color

- Adhesives - are usually off white, but can vary in colors

Scrim

- The fabric reinforcement of the tape
- It imparts strength based on the density of the fabric (scrim count)
- The yarns are woven or knitted and are composed of usually cotton, polyester or a combination of the two





Plain weave with texturized fill yarns

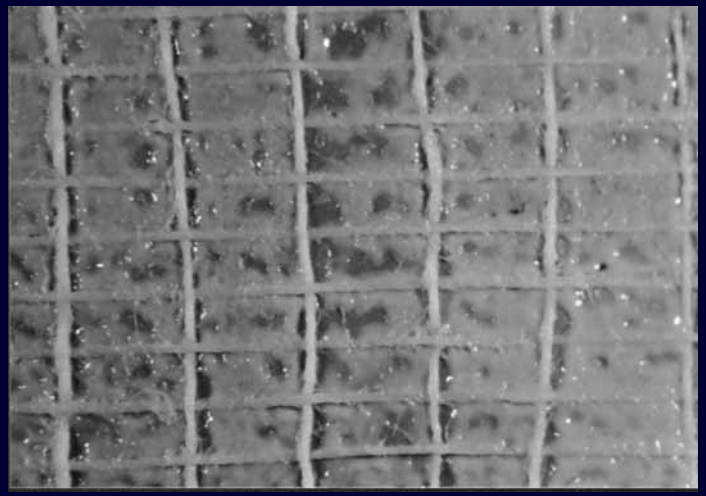
Plain weave with straight loose or bundled fill yarns

Gauze or Leno weave

Weft Insertion with texturized fill yarns

Scrim

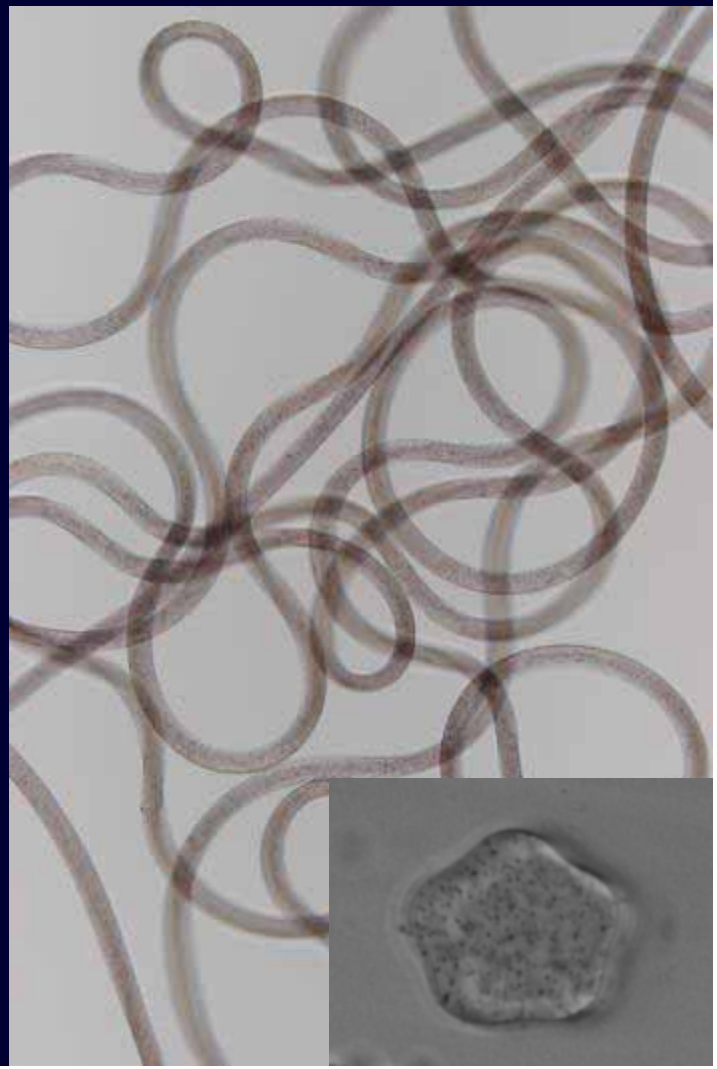
- Scrim Counts – Yarns per inch can vary between duct tapes in the warp (machine direction) and in the fill (weft) yarns. Scrim offset will vary as well.



After removal of the adhesive the scrim can be removed and analyzed with a full fiber examination

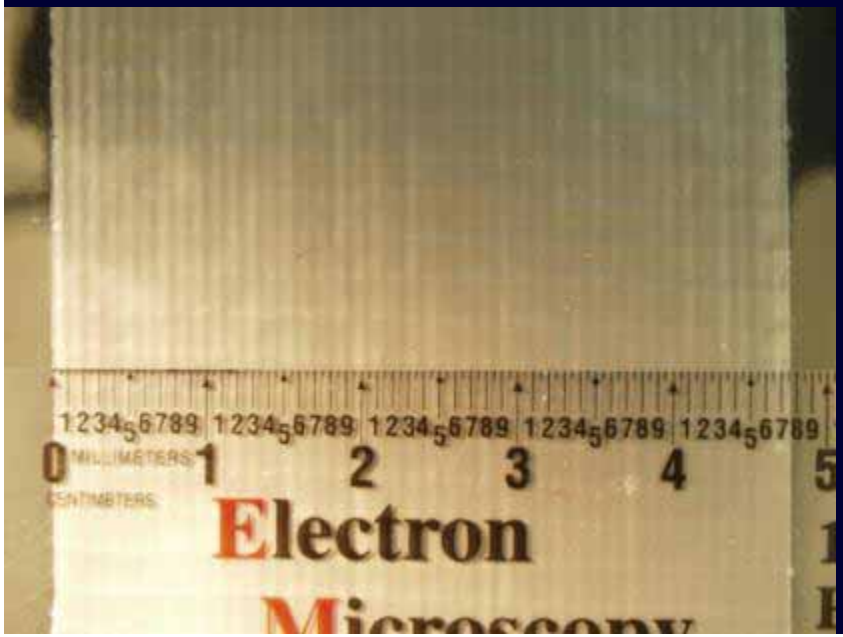
Yarn Examinations

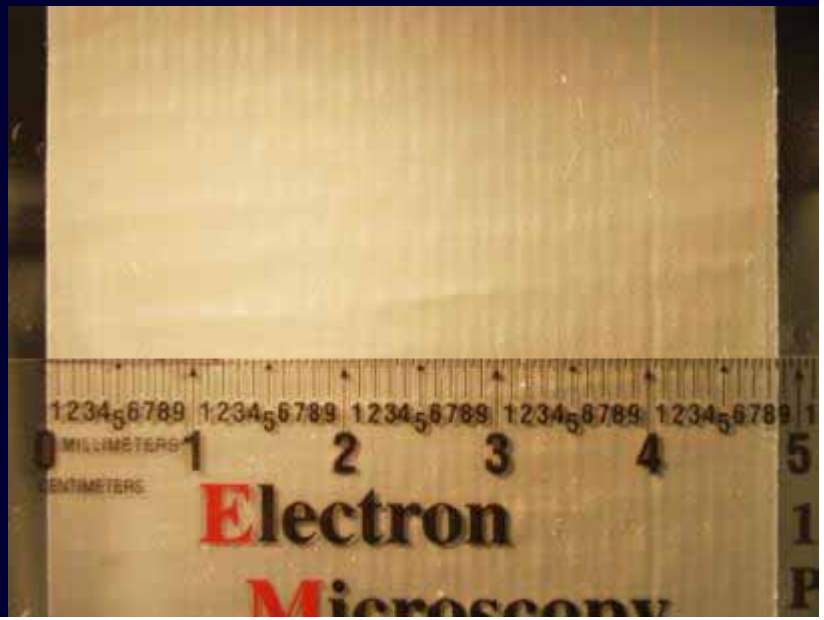
- Scrim Construction
- Identification of fibers
- Comparison Microscopy
- Polarized Light Microscopy
- Fluorescence Microscopy
- Microspectrophotometry
- Fourier Transform Infrared Spectroscopy



Tape Width

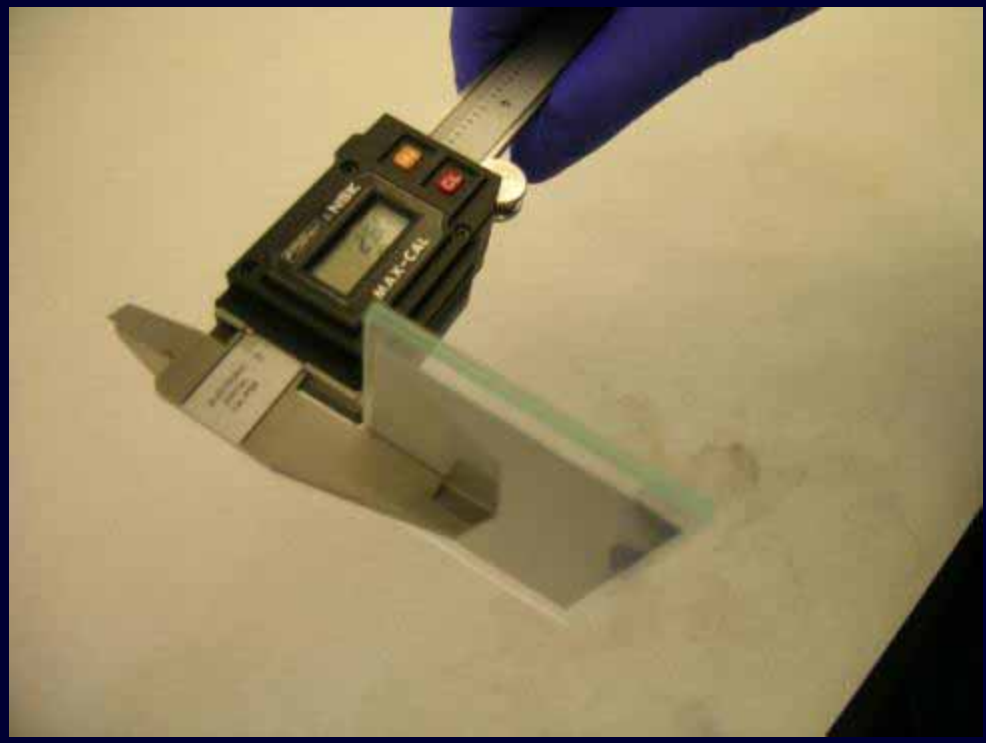
- Rolls produced in a large sheet are slit into individual rolls. Detectable differences in width between rolls of tape produced in the same batch are possible.



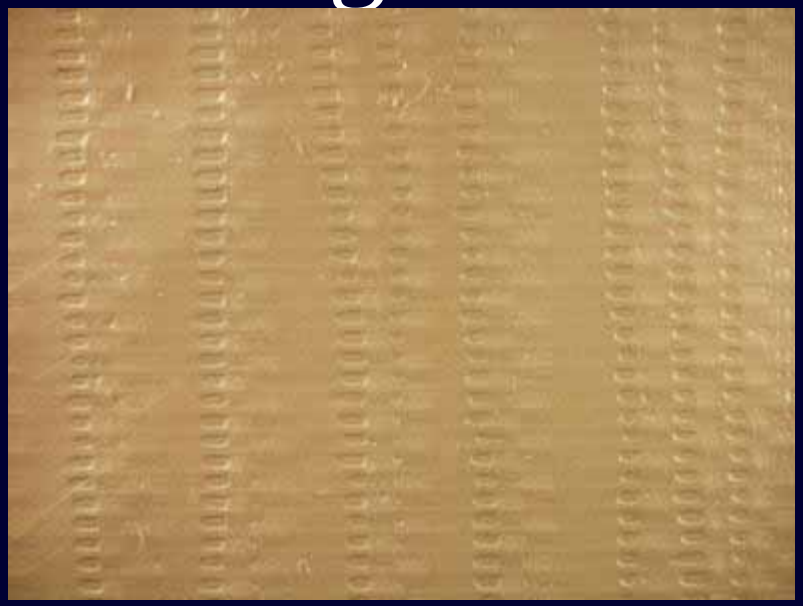


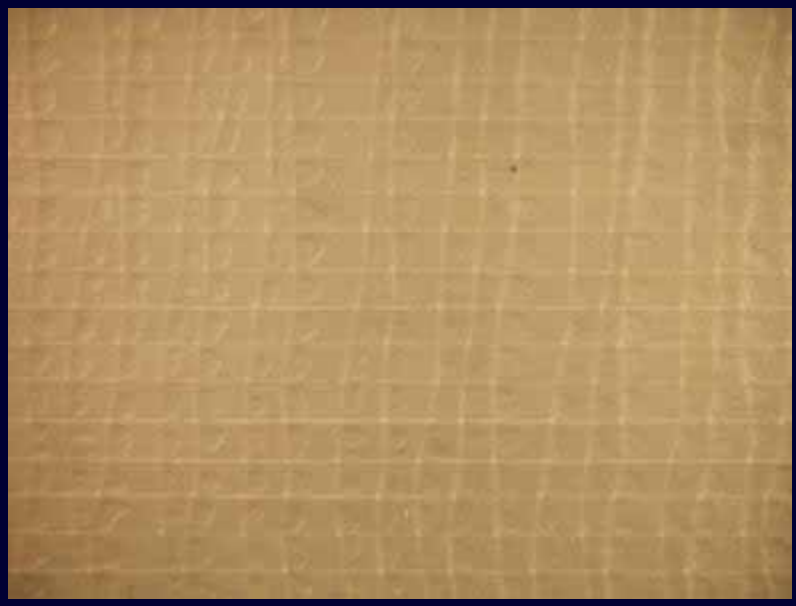
Tape and Backing - Thickness

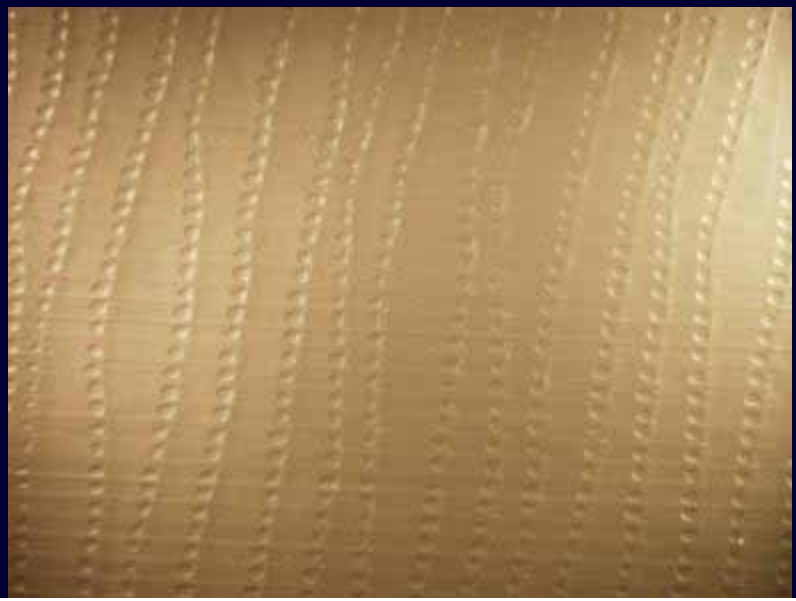
- The thickness of the tape backing and the thickness of the backing with the adhesive can vary greatly from sample to sample depending on the quality of the duct tape and the intended use.



Backing – Surface Characteristics

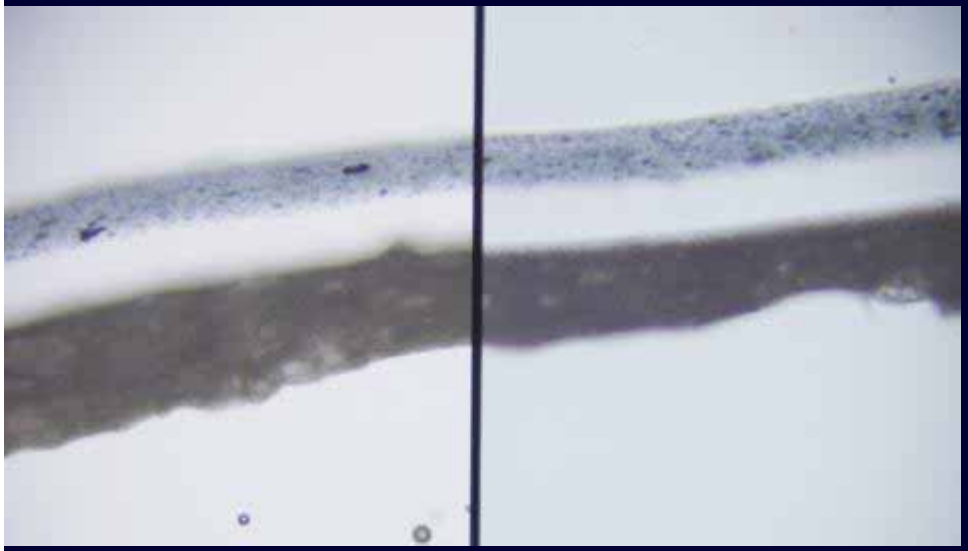






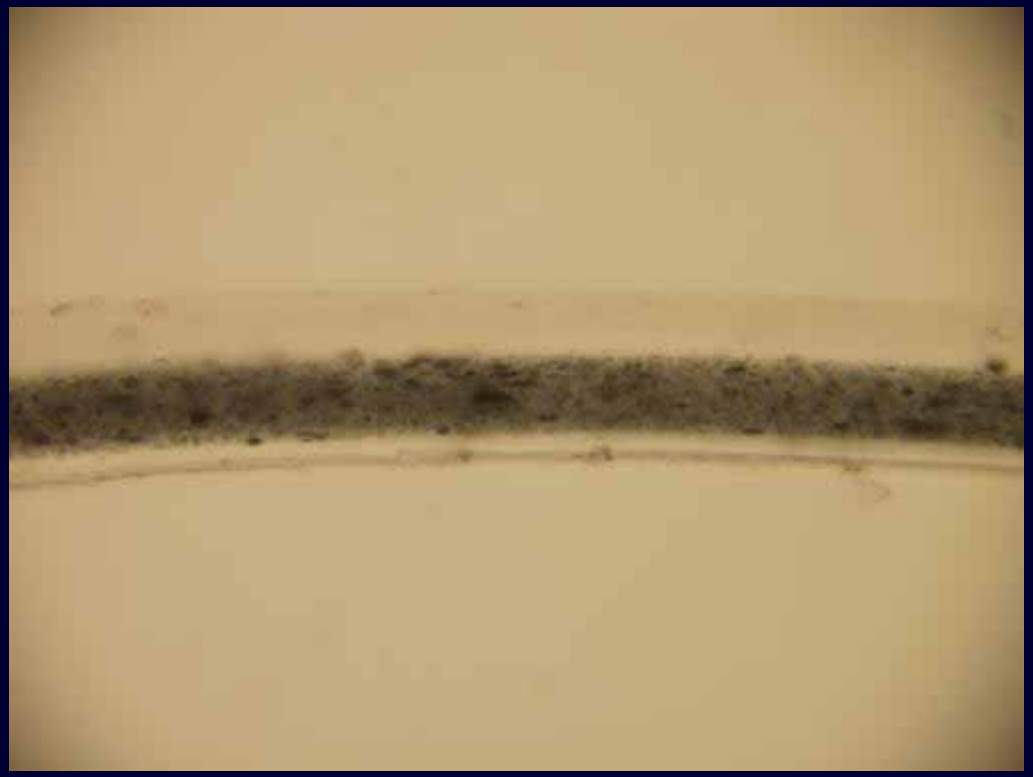
Tape Backing - Comparison Microscope

The tape backing may have multiple layers



Tape Backing - Cross Sectioning

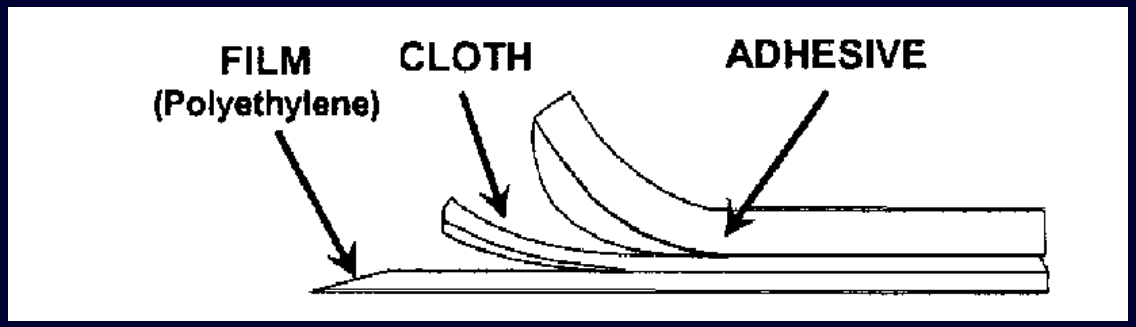
The multiple layers
should be characterized
and then analyzed
with appropriate
analytical instrumentation



Three layer duct tape backing
Adhesive removed.
400X, 10um thick

Pressure Sensitive Adhesive

- Contains one or a blend of elastomers
- Contains tackifying resins which give the ‘sticky’ nature of the adhesive
- Contains additives which increase volume or add color



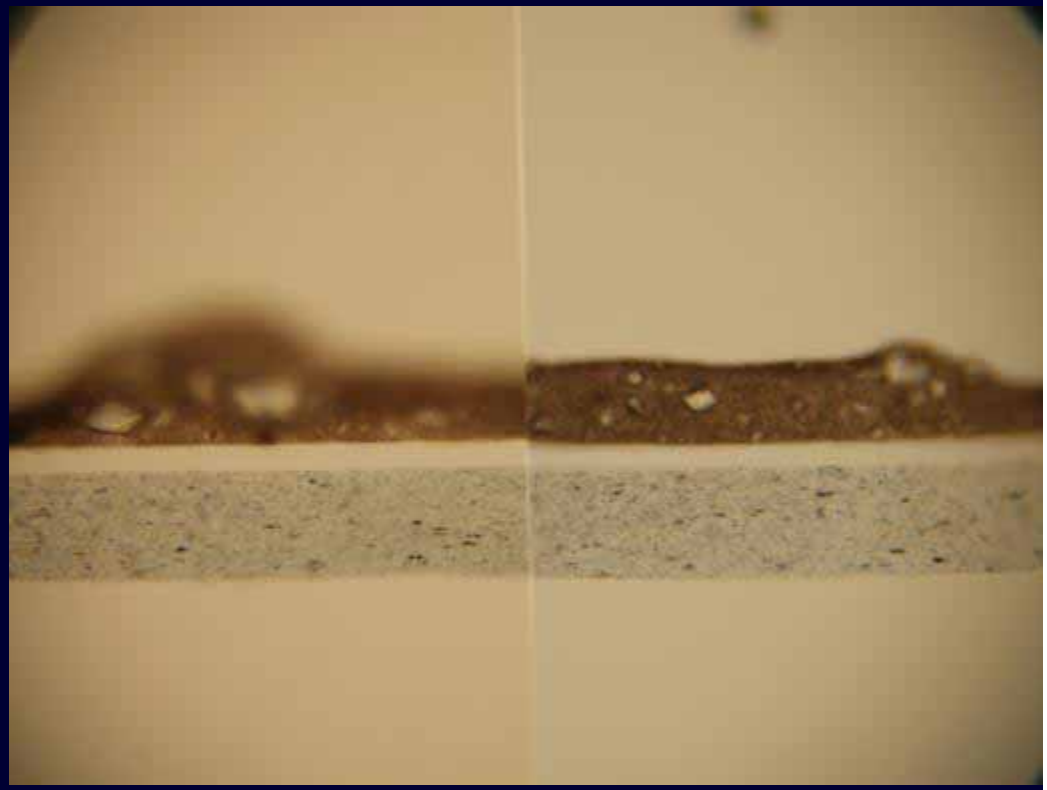
Forensic Examination of Tapes

- Guideline for Using Light Microscopy in Forensic Examinations of Tape Components – Forensic Science Communications

- April 2010

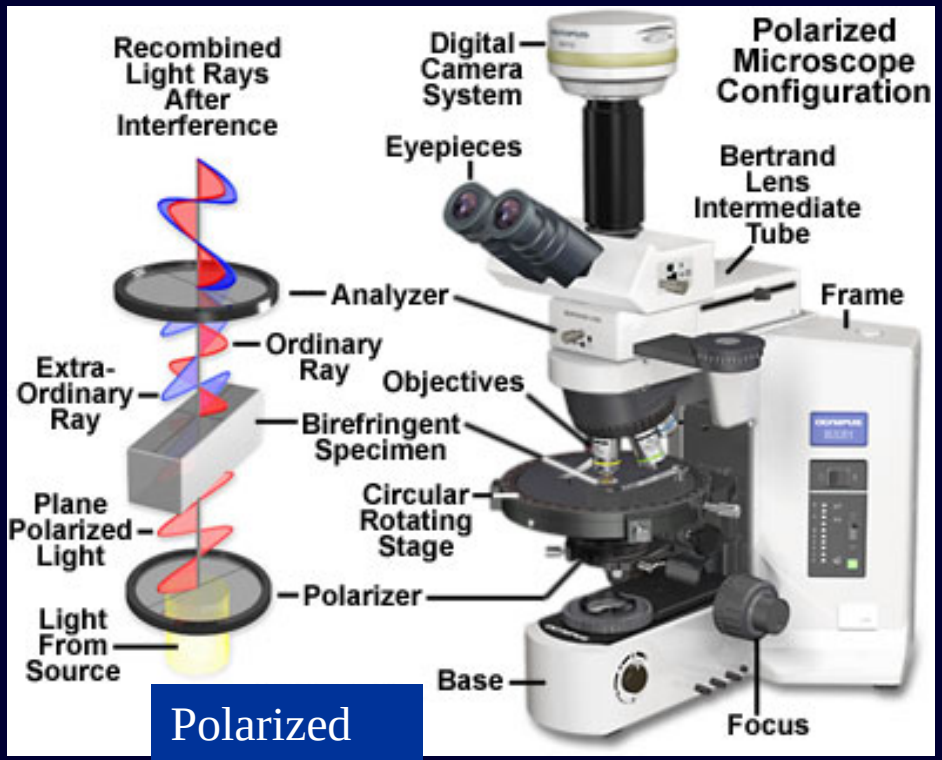
Light Microscopy of Tape Components

- Light microscopy offers a simple way to assess the similarities and differences between tape components.
- Inorganic fillers vary in type, size, and optical properties.



Light Microscopy of Tape Components

- There is variability in tape films, adhesives, and fibers that can be discriminated with transmitted and polarized light.
- Polarized Light Microscopy (PLM) is very useful in the examination orientated films

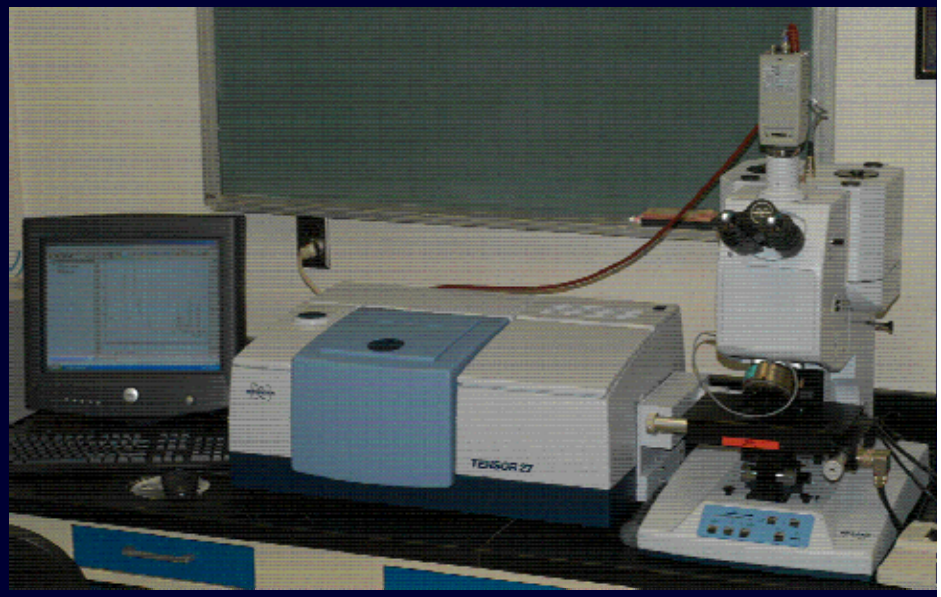


Polarized Light Microscope

Forensic Examination of Tapes

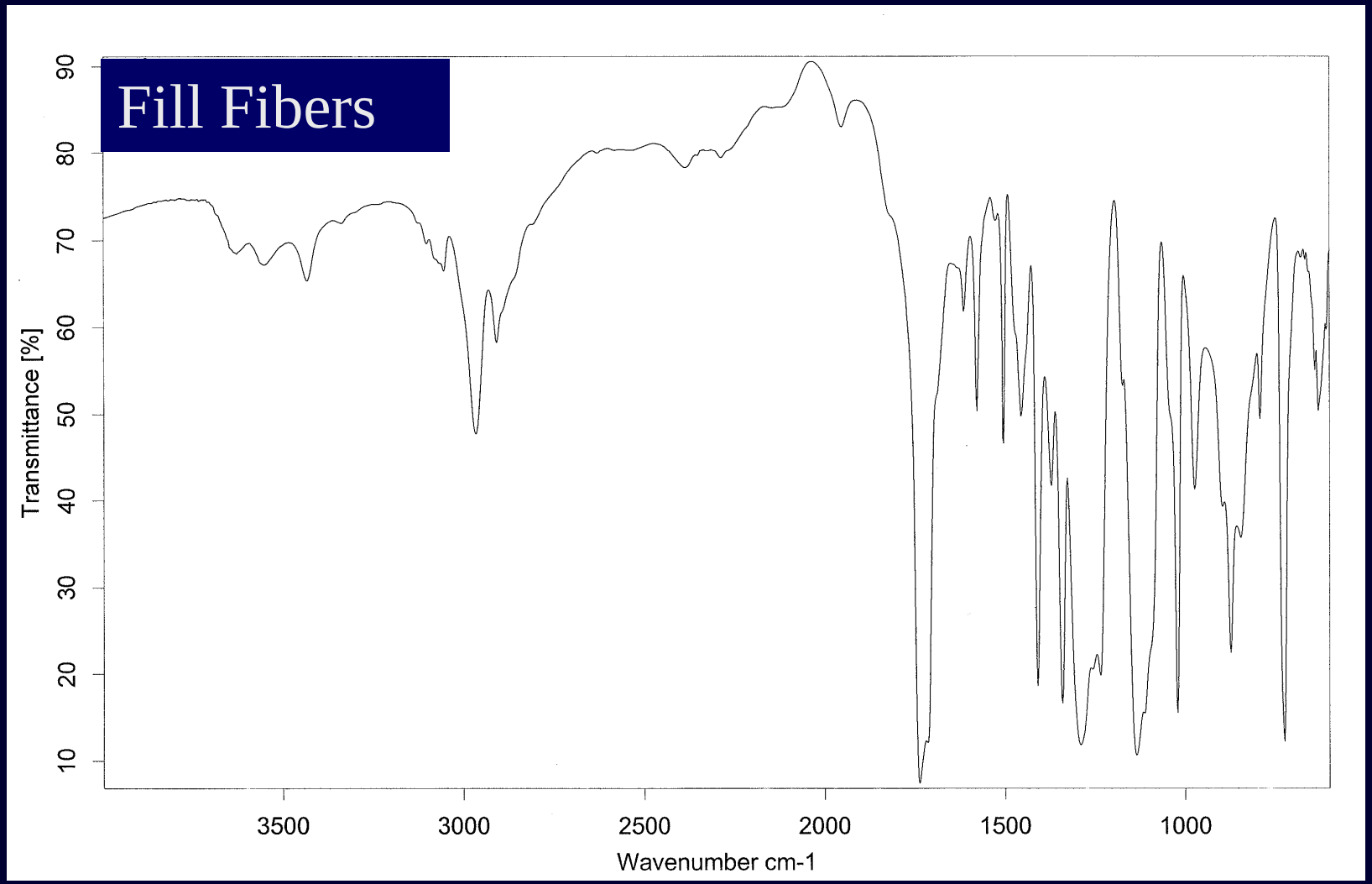
- Guideline for Using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations – Forensic Science Communications (April 2010)

FTIR is an instrumental method that uses infra-red light for identification and comparison of pressure sensitive tape components.



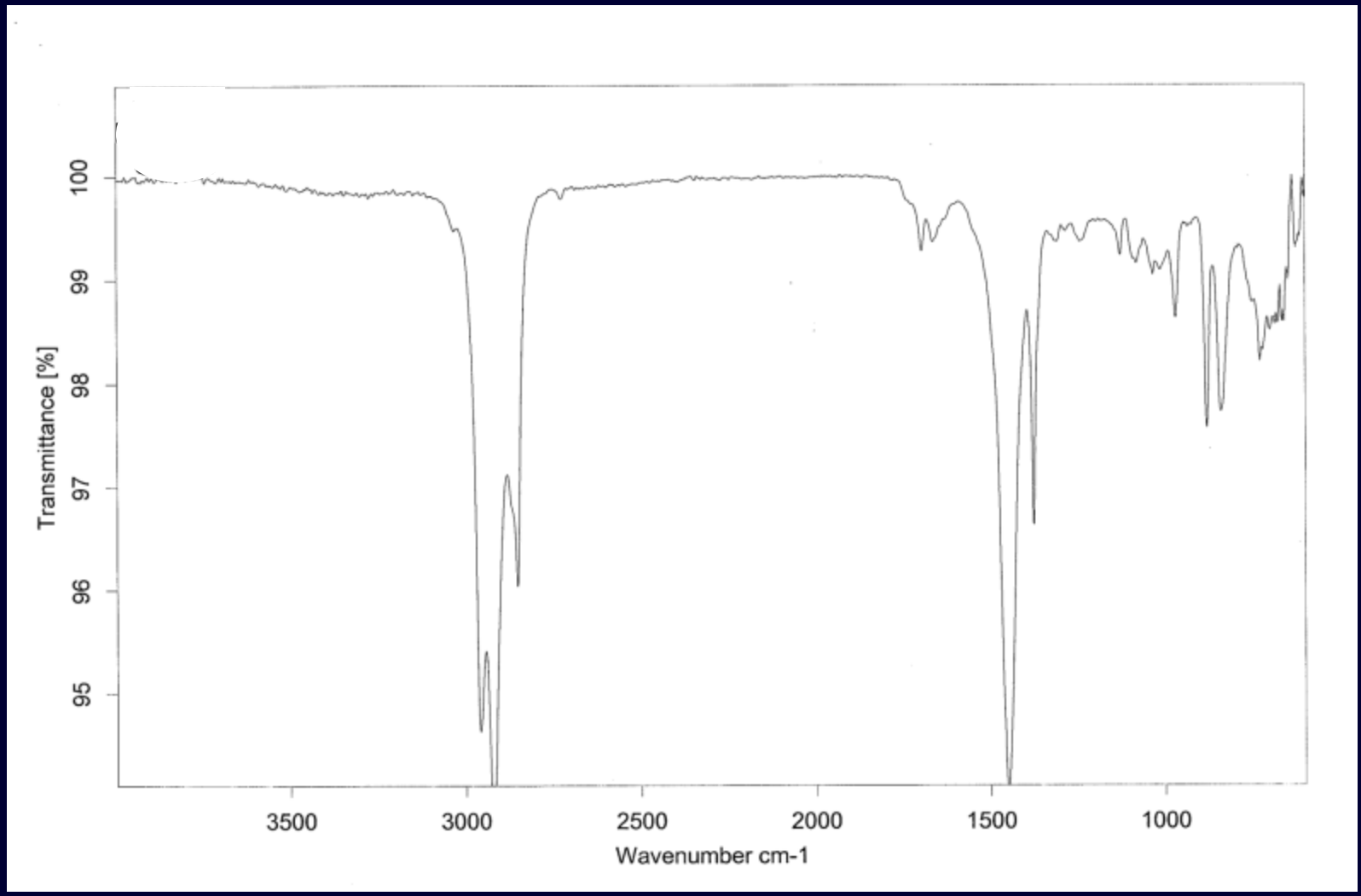
FTIR Spectra of the Scrim Fabric

Fiber Analysis



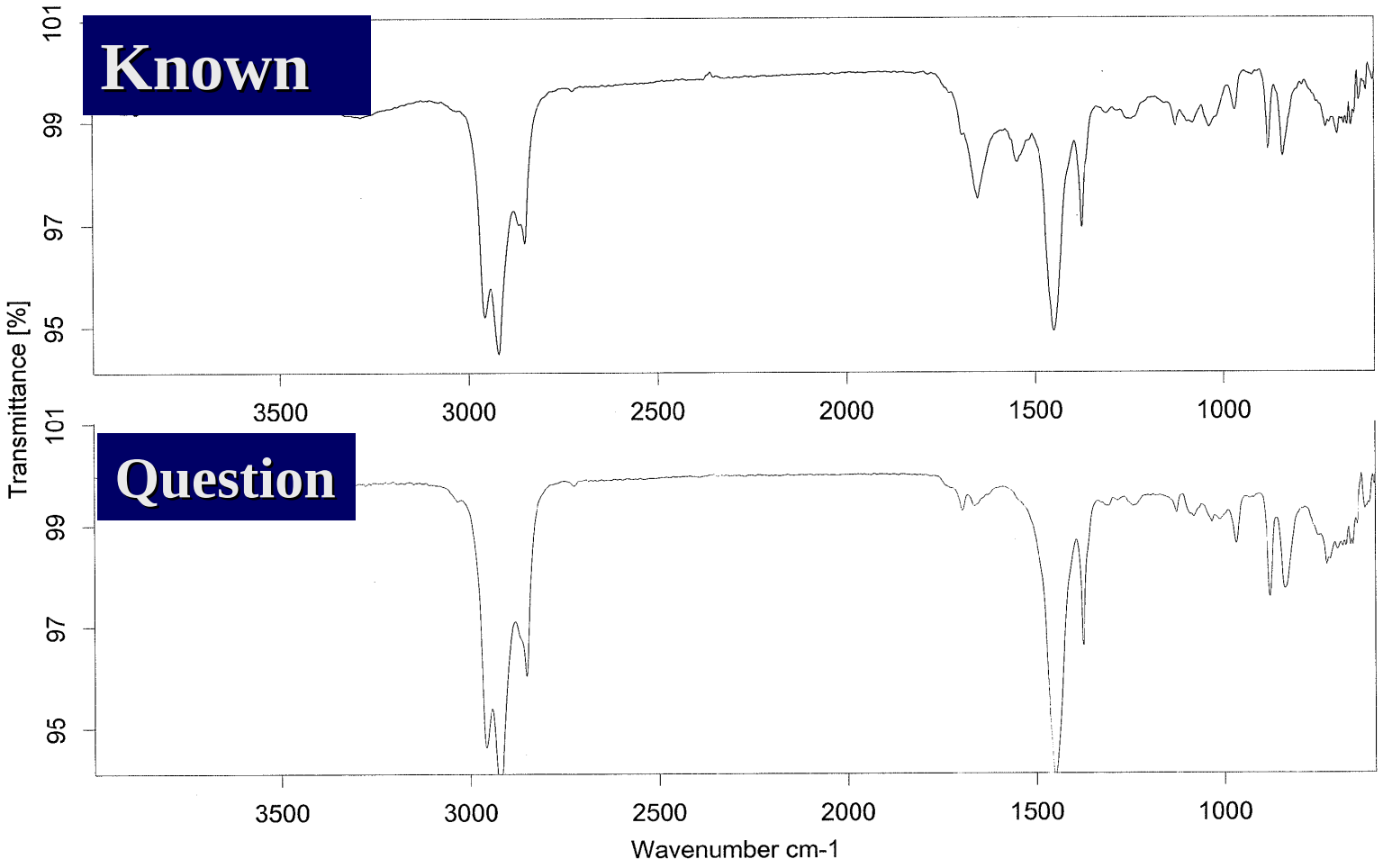
FTIR Spectra - Duct Tape Adhesive

Composition and concentrations can vary

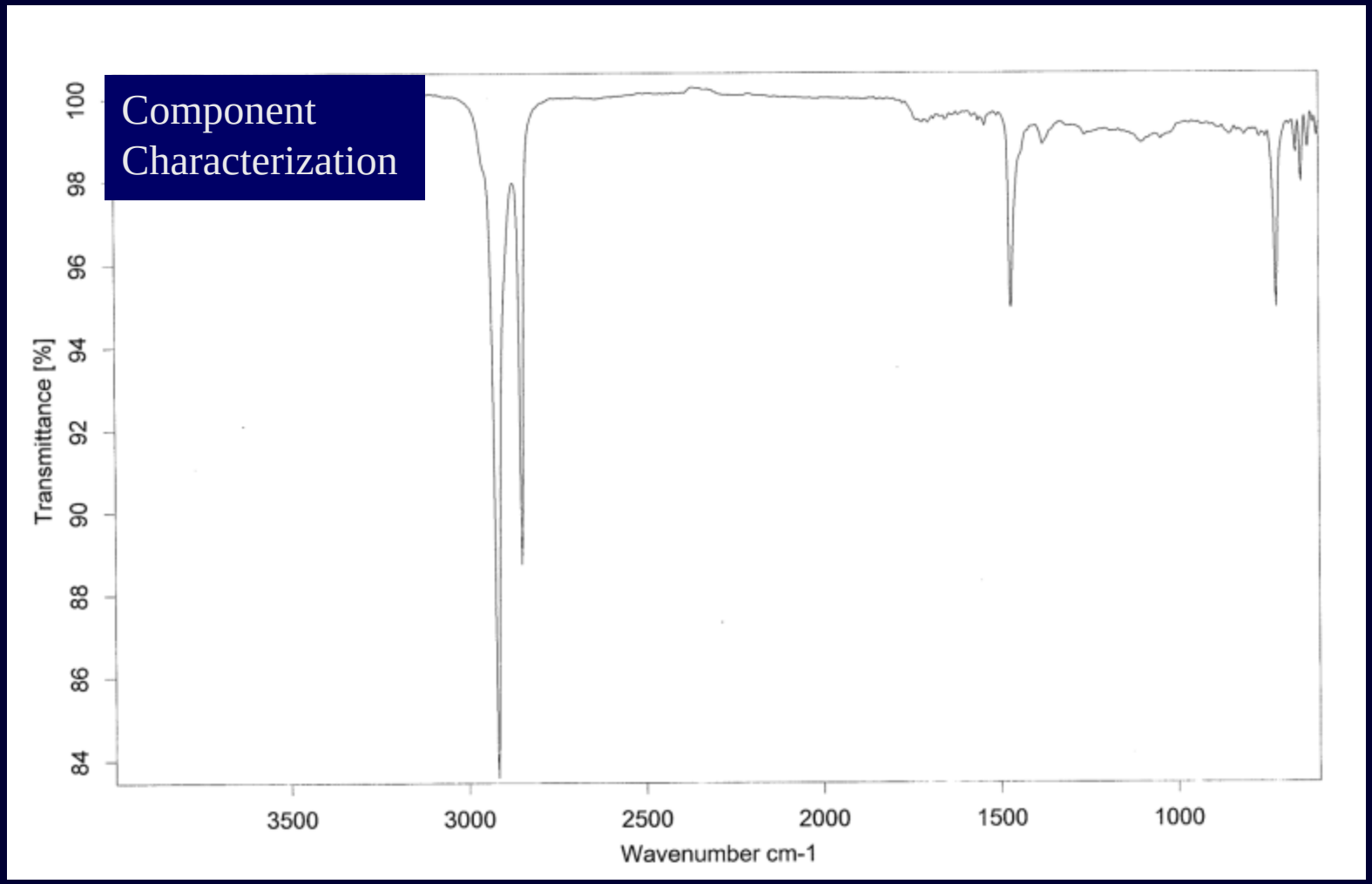


FTIR – Duct Tape Adhesive

Spectral Comparison



FTIR - Duct Tape Backing



Elemental Techniques for Tape

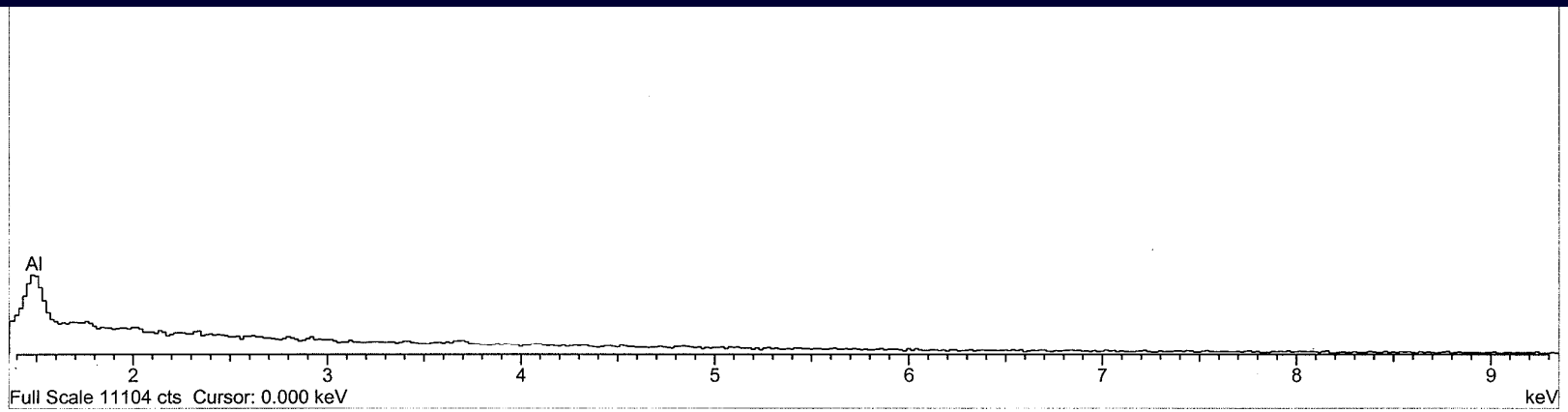
- Elemental techniques can be used to differentiate inorganic constituents
- Possible techniques include SEM-EDS, XRF, ICP, and XRD.
- SEM has imaging capabilities to evaluate surface topography of tape

Scanning Electron Microscope (SEM)

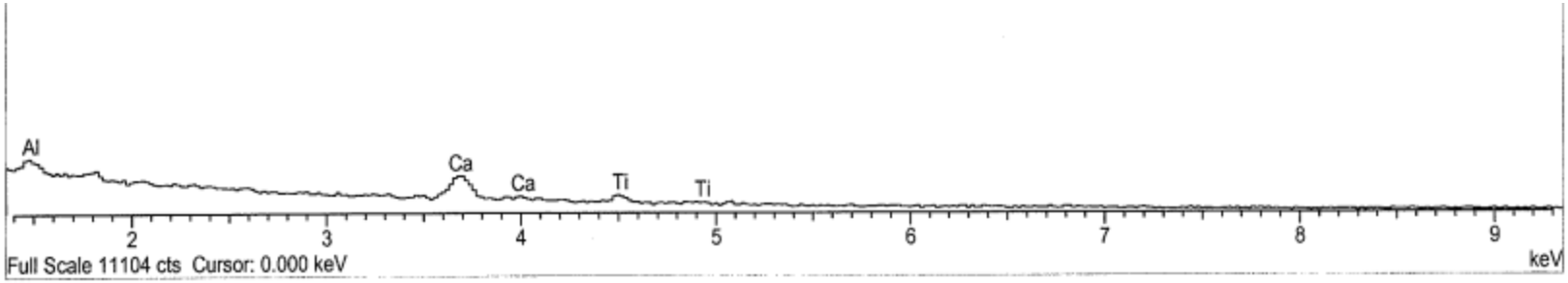
Guideline for Using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy in Forensic Tape Examinations – Forensic Science Communications

Tape - Elemental Analysis

Two Layer Duct Tape Backing



Duct Tape Backing – Top Side

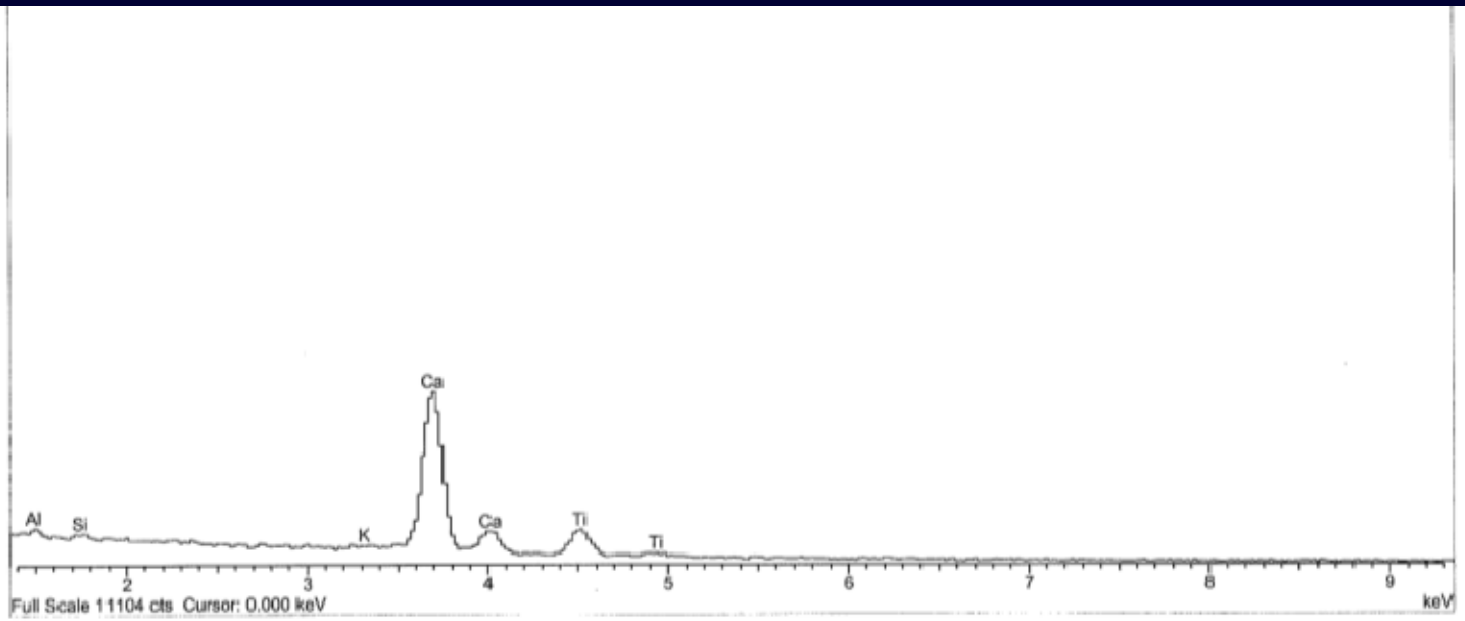


Duct Tape Backing – Adhesive Side

Tape - Elemental Analysis

Duct Tape Adhesive

Inorganic composition and concentration can vary

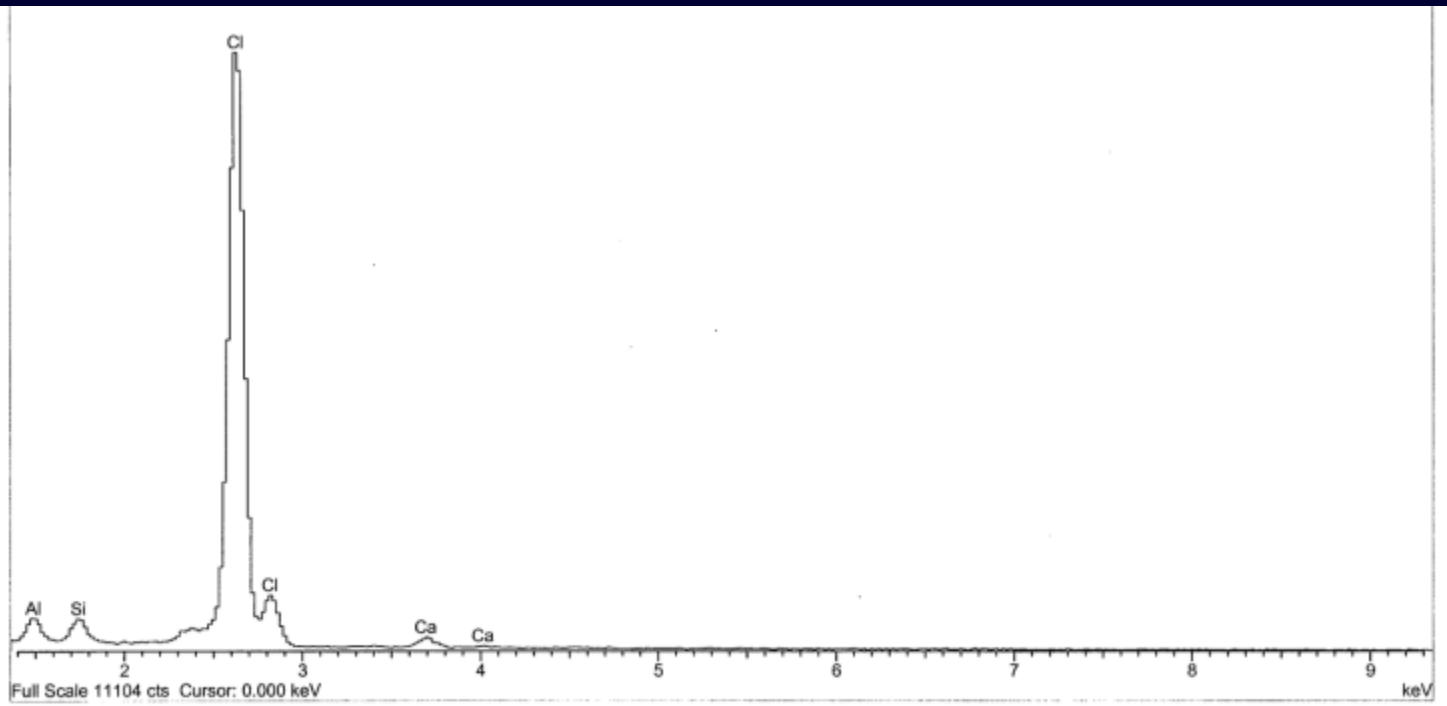


Duct Tape – Adhesive

Tape - Elemental Analysis

Electrical Tape Backing

Inorganic composition and concentration can vary



Electrical Tape - Backing

Tape Conclusions

- The two tapes possess a physical end match, therefore the pieces of tape were once connected to and part of the same piece
- Questioned tape(s) exhibit the same characteristics and chemistry to the known sample, therefore are consistent with having come from the known source (roll)
- Questioned tape(s) is dissimilar to the known sample ,therefore it could not have originated from the known sample (roll)

Daubert Guidelines

- Has the theory or technique been tested
- Has the theory or technique been subjected to peer review and publication
- Are there standards controlling the technique's operation
- Is there a known or potential rate of error
- Is the theory or technique generally accepted

Tape Variability - Theory

Since tape can vary in physical construction and in chemical composition from one roll to another and the physical and chemical characteristics are consistent throughout a single roll of tape - an association is possible between question and known tapes.

This belief is supported by the literature. Even though every roll of tape has not been tested, all the studies help validate the theory.

Tape Variability - Theory

- Different rolls of the same class of tape can vary in physical construction and in chemical composition.

  The examination of pressure sensitive adhesive tapes, Johnston

  The forensic value of duct tape comparisons, Smith

  Forensic examination of duct tape, Benson

  Duct tape analysis as trace evidence, Snodgrass

  The characterization of PVC adhesive tape, Kee

  Forensic characterization of black polyvinyl chloride electrical tape, Keto

Tape Variability - Theory

- The physical and chemical characteristics are consistent throughout the roll of tape.

  The Tapes with Adhesive Backings: their Characterization in the forensic science laboratory, Blackledge

  Analysis of pressure sensitive adhesive tape, Merrill

  Elemental examination of silver duct tape using energy dispersive x-ray spectrometry, Jenkins

  Forensic characterization of black polyvinyl chloride electrical tapes, Keto

Technique Testability

- Numerous articles have been published on the forensic analysis of different types of tape
  - *Duct tape analysis as trace evidence, Snodgrass*
  - *Identification of pressure-sensitive adhesive polypropylene tape, Sakayanagi*
  - *Forensic characterization of black polyvinyl chloride electrical tape, Keto*
  - *Comparisons of masking tapes by fluorescence spectroscopy, Blackledge*
  - *Microscopical examination of polymer films, Rappe*
  - *Elemental composition of packaging tapes using HR ICPMS, Dobney*

Technique Testability

- Numerous articles have been published on the techniques used specifically for forensic tape comparisons
  - *A validation study for duct tape end matches, Bradley*
  - *A new approach for the analysis of duct tape backings, Hobbs*
  - *Microscopical examination of duct tape adhesive fillers, Randle*
  - *PLM examinations of clear polymer films, Smith*
  - *Measurement of the principle refractive indices of orientated polymer films, Rappe*
  - *The comparison of PVC tapes by pyrolysis gas chromatography, Williams*
  - *Advances of infrared ATR analysis of duct tape, Merrill*

Peer Review

- Scientific papers on tape are peer reviewed
  - *ASTM*
  - *Forensic Science Communications*
  - *J. Analytical Atomic Spectroscopy*
  - *J. Anal. & Appl. Pyrolysis*
  - *J. Polymer Science*
  - *J. Forensic Science*
  - *The Microscope*
  - *Regional Forensic Society journals*
  - *Symposium Proceedings*

Tape Resources

- Scientific information on pressure sensitive tape
  - *Pressure Sensitive Tape Council*

Books

- *Pressure Sensitive Adhesive Tape*
- *Adhesives and Adhesive Tapes*
- *Forensic Analysis on the Cutting Edge*

Forensic Tape Articles

- *Regional Forensic Society journals*
- *Symposium Proceedings*

Standards Controlling the Techniques

- Forensic scientists address tape examinations in a formal setting
  - Scientific Working Group for Materials Analysis (SWGMAT)
    - Guideline for the Forensic Examination for Pressure-Sensitive Tape
    - 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
  - European Paint & Glass Working Group (EPGWG)

Standards Controlling the Techniques

- Laboratory Examination Guidelines
- American Society for Testing and Materials (ASTM)
  - Guidelines for the countless techniques on microscopy, polarized light microscopy, FTIR, SEM/EDS, ICP, and Pyrolysis GC/MS including general use techniques
  - Guidelines for adhesives, fibers, fabric, plastics, and rubber
  - Twenty-seven active guidelines specifically on the testing methods and specifications for pressure sensitive adhesive tapes

Error Rate

- The following can be stated:
  - The scientist meets the educational requirements for the position
  - The scientist received the job specific training for the analysis and comparisons of tape
  - The scientist successfully completed the competency testing before starting tape examinations
  - The scientist successfully continues to complete annual proficiency testing

Error Rate

- Every case is subjected to both a peer and administrative review
- A qualified examiner using the proper equipment and following a generally accepted protocol should have a low rate of error
- The examiner's education, training, experience, equipment, and procedures are continually updated
- Corrective actions and preventative actions continually lower the error rate

Tape Analysis and Testing

- Analysis of tape is not unique to forensic science, industry is also interested in being able to characterize tape
- Proficiency tests
  - An external proficiency test designed specifically for forensic tape examinations is available.

Error Rate

- A forensic scientist's rate of error cannot be precisely determined for a tape examination for a specific tape exhibit(s) at a given time, location and with the procedures used for a given examination.
- The following can be stated:
  - While we don't know the error rate in a specific case given the particular analytical process, we are confident in our findings for they have been subjected to a host of quality control mechanisms ensuring their reliability.

General Acceptance

- Comparative biology has a long history of microscopic identification and comparison dating back to the 18th century
- The combination of microscopic and instrumental techniques provide for a highly discriminating means to examine and compare tapes
- The instrumentation used in the analysis and comparison of tape have been utilized by the scientific community for many years

General Acceptance

- The various analytical methods are used by non-law enforcement laboratories
- The forensic comparison of tape is a generally accepted theory based on literature in the previously described peer reviewed journals and in forensic text books.

General Acceptance

- Federal, state and local/city laboratories, as well as European laboratories conduct forensic tape examinations.

- In May of 2000, surveys were mailed to 320 Crime Labs who were in the ASCLD/LAB data base. 89 surveys were returned by labs that do forensic tape examinations. The results indicate laboratories conduct similar types of forensic tape examinations.

Previous Court Decisions

- 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 Bishea's duct tape reconstruction testimony because the Government has proven that it is scientifically reliable under Daubert."

Conclusion

- Tape analysis can be a valuable type of physical evidence and the examination meets the guidelines of a Daubert challenge