## D44 Discrimination of Duct Tape Samples Using FTIR, SEM/EDS, and XRD Analysis

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The analytical approach taken when comparing two pieces of duct tape to ascertain whether they may share a common origin will be presented. Examples of the discrimination power of each step within the process will be discussed. The steps will include macroscopic and microscopic observations, physical measurements, and the following analytical instrumentation: FT-IR, SEM/EDS, and XRD. After attending this presentation, the attendees will understand the importance of the sequence and discrimination power of each of the examinations.

This presentation will impact the forensic community and/or humanity by educating the forensic community regarding the differences that can be measured between two seemingly consistent pieces of duct tape. The technique of X-ray diffractometry is not commonly used in the forensic community; a case will be highlighted that demonstrates the importance of using this technique to discriminate between two pieces. Without this technique, there is the potential to draw an incorrect conclusion regarding an association between two specimens of duct tape.

In the FBI Laboratory, comparative analyses of duct tape specimens begin with macroscopic and microscopic examination of the physical appearance of the submitted evidentiary items. The adhesive color and backing construction as well as the thickness of the film backing and the overall tape thickness are all discriminating physical features between specimens. Fabric scrim characteristics such as the number of yarns per square inch in the warp (machine) and fill (cross) directions, and the type of fabric weaves are also used to physically compare duct tape samples.

If these physical characteristics do not provide points of discrimination between items of evidence, particularly in cases where the evidence has become aged or degraded, instrumental methods of analysis can be extremely useful. In the FBI Laboratory, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy with energy dispersive X-ray analysis (SEM/EDS), and X-ray diffraction (XRD) analyses are routinely used to analytically compare duct tape specimens. Each technique requires minimal to no sample preparation and can be performed on specimens no larger than a one-inch square. Information regarding the additives used in the formulation of both the adhesive and the backing can be obtained using all three techniques. When used in concert, the discriminating power between physically similar specimens becomes much greater.

FTIR may be used to analyze filler materials in the adhesive layer of duct tape samples. Common materials that may be identified using FTIR include: talc, clay, calcium carbonate, and titanium dioxide. The absence or presence of any of these components in only one of the specimens being compared will readily disassociate the two samples.

SEM/EDS can be used to further compare both the film backing and the adhesive layer of two or more specimens in order to determine if there are differences in the elemental composition of either component. SEM/EDS data can reveal the presence of titanium, calcium, magnesium, or aluminum, even when these materials are not apparent from the FTIR data of the adhesive. Analysis of the adhesive and backing layers separately provides the analyst with two independent points of comparison between specimens. Thus, comparable data in one layer between specimens may be countered by differences in the other layer, which would serve to disassociate specimens that might otherwise be reported out as being consistent with one another.

When a method that complements SEM/EDS, such as XRD, is added to a duct tape analysis protocol, even further discrimination can be achieved between seemingly consistent specimens. In the FBI Laboratory, XRD is used to document the mineralogical aspects of both duct tape layers, either together or separately. Common diffraction patterns that are encountered in duct tape specimens include titanium dioxide (anatase or rutile forms), kaolin clay, talc, polyethylene (film backing), calcium carbonate, and dolomite.

In the case that will be discussed, physical comparisons between a severely weathered specimen and a partial roll of duct tape in pristine condition were conducted. These examinations revealed that similar specifications were used in the formation of the blown film backing. The relative backing and overall thickness measurements of the duct tape specimens were also comparable. The fabric scrim count in the warp (machine) and fill (cross) directions indicated that both were readily available consumer grade products and the weave of the scrim depicted a weft insertion pattern. Analysis of the adhesive using FTIR indicated that calcium carbonate was present in both specimens. Neither talc nor clay were observed in either sample, and the typically prominent absorption bands for titanium dioxide were less than obvious. SEM/EDS data showed that the adhesive did contain titanium and oxygen in both samples, and a small amount of magnesium was present in the film backing of the partial roll of duct tape. However, XRD analysis proved to be essential

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in this examination for it provided two important discriminating features: the form of titanium dioxide that was present in the adhesives; and, that talc was found in the backing of the partial roll of tape, but not in the questioned sample. Thus, two seemingly physically and chemically consistent specimens were determined to be different in what is often assumed to be a less discriminating feature of duct tape.

**Duct Tape, X-Ray Diffractometry, Discriminating Power**

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