CASE STUDY

Infrared Spectroscopy

Spotlight FT-IR Imaging System Helps Forensic Lab Win Triple Murder Conviction

Most criminals do not realize that a microscopic speck of paint could put them behind bars. For example, analyses using infrared microspectroscopy performed by the Michigan State Police Forensic Science Division (MSPFSD), Lansing Laboratory, helped to win a triple murder conviction by matching paint from one victim's clothing to the murderer's car. MSPFSD forensic scientists found a microscopic paint chip on the hit-and-run victim's clothing, then associated each of its five layers to a chip taken from the van driven by the perpetrator. This evidence played a significant role in the killer's conviction for the third murder that he committed that day, a case that was otherwise puzzling because there was no known connection between killer and victim.

A 35-year-old Michigan resident had just stabbed his ex-girlfriend and her friend and was driving away from the murder scene at high speed in his van. According to witnesses, he then struck a jogger less than an hour later as the jogger crossed the street. The jogger was not injured and moved onto the sidewalk to dust himself off as the assailant sped away. A few seconds later, the assailant's van emerged again after driving around the block, jumped up onto the sidewalk and struck the jogger again, this time killing him.

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Forensic evidence crucial to murder case

Prosecutors alleged that the assailant committed the first two murders because he was jealous that his ex-girlfriend was dating the other victim but had no idea of the motive in the jogger's death. The assailant pleaded no contest to the first two murders but said that he had no recollection of killing the jogger and pleaded innocent. Thus, forensic evidence was critical to the case against the assailant in the third murder.

The case was assigned to Christopher Bommarito, Forensic Scientist at the MSPFSD. The MSPFSD has approximately 150 scientists and their customers are the Michigan State Police as well as local and county police and fire departments throughout the state. Bommarito has extensive experience in the analysis of trace evidence including paint, glass, filaments, fibers, footwear and explosive residue. He has testified approximately 200 times in federal and state courts in six different states in relation to these analyses. He has also assisted and advised various federal and state authorities on clandestine drug laboratory investigations and other enforcement activities (Figure 1).

Figure 1. Fiber under microscope.

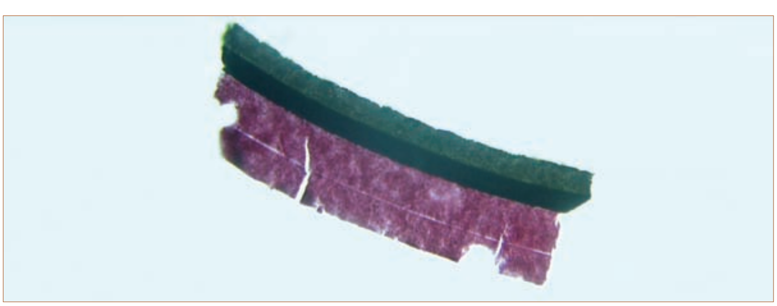

Figure 2. Cross-section of paint under microscope.

Finding a sample on the victim's clothing

Bommarito began his investigation by carefully examining the victim's clothing under a microscope, looking for a tiny paint chip. He was relying upon Locard's Exchange Principle, developed by Dr. Edmond Locard, which is a cornerstone of the forensic sciences. This principle states that when any person comes into contact with an object or another person, a cross-transfer of physical evidence occurs. Bommarito said that in a case where a vehicle strikes a person, he is nearly always able to retrieve paint evidence from the victim's clothing, as long as the victim came into contact with the painted portion of the vehicle (Figure 2).

Fourier Transform Infrared Spectroscopy (FT-IR) is by far the most popular instrument for analyzing paint evidence today. An FT-IR instrument measures the absorption of infrared (IR) energy, over a range of wavelengths, as different bonds in the molecule vibrate and move in characteristic fashions. This produces a "fingerprint" spectrum of a sample unique to that material. Coupling an FT-IR instrument to an IR microscope allows the IR light to be focused onto a small area allowing these high quality spectral "fingerprints" to be obtained from small samples or small areas of samples – as is often required in forensic analyses.

Challenges involved in paint evidence

"Obtaining an association between two paint chips using FT-IR is complicated by several factors," Bommarito said. "First of all, the particles transferred to the victim's clothing are typically extremely small, 10 microns by 10 microns is not unusual. Second, automotive paint chips typically consist of four or five layers of different materials and obtaining an association between the two chips requires separately analyzing each layer. There are several critical requirements in any instrument that we use for this analysis task. First of all, high spatial resolution is required in order to obtain spectra for the individual layers of the chip. Secondly, very low noise on the IR signal is required in order to obtain valid data from such small samples. The noise of an FT-IR instrument is usually defined by its signal-to-noise ratio – the higher this ratio the less noise will be seen in spectra. An FT-IR instrument's signal-to-noise can be improved by increasing data acquisition times, however, this is undesirable as it has an obvious, direct affect on total analysis time and therefore reduces the sample throughput of the laboratory. Third, paint samples tend to have absorbencies in the wavenumber range from 550 to 650, so an FT-IR instrument should detect IR radiation with a high signal-to-noise ratio in that range (Figure 3).

The MSPFSD primarily uses the Spectrum™ Spotlight™ 300 FT-IR imaging systems from PerkinElmer®, Inc., Shelton, Connecticut. "We have used PerkinElmer instruments for seven or eight years but upgraded recently to the new Spotlight 300 because it offers a number of advantages," Bommarito said. "First of all, the detection range of the medium range MCT has been improved to allow measurements to be made in the 550 to 650 wavenumber range which is helpful because there are pigments in paints that have absorbencies within that range. In addition, the spatial resolution and signal-to-noise ratio of the new instrument are both unusually high."

The PerkinElmer Spectrum Spotlight 300 includes a revolutionary detector design that provides the MCT array detector and a single point MCT detector in the same dewar. The array technology allows the collection of high quality IR chemical images of large sample areas quickly and easily while for the most challenging samples, the single point detector provides the ultimate IR sensitivity and spectral range. The single element MCT detector in the Spectrum Spotlight has a smaller area than earlier FT-IR microscopes (100 µ compared with 250 µ). Background noise is generated from areas of the detector not illuminated by the sample signal – therefore the smaller the redundant area the lower the noise. This very high signal-to-noise is the primary reason why the Spectrum Spotlight can continue to make valid IR measurements in areas of the spectra below 650 cm^{-1}. In addition, the Spectrum Spotlight 300 is the first FT-IR microscope to use white light LED illumination with wide range brightness and contrast controls producing extremely high quality visible images enabling very small forensic samples and the thin layers within the paint-chip samples to be quickly located for IR sampling.

Confirming an association between the paint samples

After finding paint samples on the victim's clothing, Bommarito visually compared them to samples from the assailant's car and determined they were visually similar. He then mounted the chips in wax and cut cross-sections with a microtome.

He placed each cross-section on a potassium bromide slide and mounted them on the FT-IR instrument stage. He then generated a visible image on the screen and specified an area for each of the five layers from which infrared spectra were to be obtained. The instrument focused the infrared radiation through the sample and measured the absorbed and transmitted light for each frequency, plotting a graph of wavelength versus percent transmittance. The sample is then moved over the linear MCT array to generate, in real time, an IR image of the layer comprising hundreds of spectra as a false color visible image. Following this process for each layer in the two samples, Bommarito confirmed an association between each layer in both samples and testified to his conclusions in the assailant's trial in the jogger's murder.

The assailant was convicted of murder

In addition to the paint evidence, prosecutors in the assailant's trial also introduced evidence from witnesses to the slaying and other forensic evidence, such as tissue found on the van. One of the victim's relatives also testified that she visited the assailant in jail and asked him: "Why the jogger?" and that the assailant told her: "I thought it was my ex-wife's boyfriend." A jury found him guilty of the murder and he was sentenced to a third term of life in prison. "This was a tragedy, and we felt that our evidence was overwhelming and that it was premeditated and done during the commission of a serious felony. He is a dangerous, dangerous man," said the prosecutor.

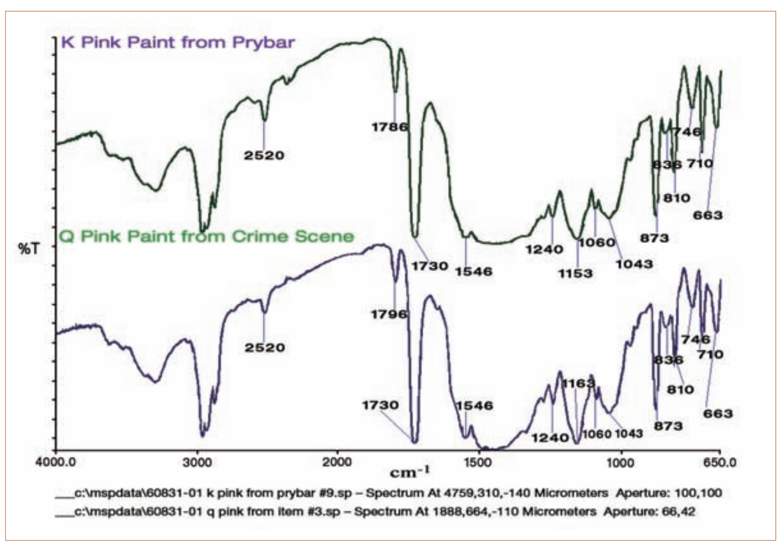

Figure 3. Comparison of FT-IR spectra from two paint samples.

Conclusion

Bommarito said that the MSPFSD has progressed beyond finding an association between a paint sample and suspect vehicle to identifying vehicle model, make, year and color even in cases where there is no suspect vehicle. The Royal Canadian Mounted Police (RCMP) and the Federal Bureau of Investigation (FBI) has recently created a database consisting of FT-IR results from paint samples taken from a wide range of different vehicles. The MSPFSD has integrated the Spectrum Spotlight 300 FT-IR with the library searching tool. This software takes the results of an FT-IR scan and finds matches within the RCMP's Paint Data Query System database. "This provides an example of the future of forensic science in my opinion," Bommarito said. "We are moving beyond simply providing evidence for or against a suspect to providing investigative leads. This technique has already led to the identification of suspect vehicles in several previously unsolved hit and run cases."

The Spectrum Spotlight 300 Imaging System described in this case study has been superceded by the Spotlight 400 FT-IR Imaging System.

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