Rising, Converging Image Analysis Tools for Forensics—Even Out in the Field

A purple fiber was the undoing of Wayne Williams, a serial killer who stalked young boys in the Atlanta area from 1979 to 1981. Microscopy was a deciding factor in matching fibers found on several of the victims to those from Wayne's chenille bedspread. As decisive as the findings were, fiber microscopy has always been difficult. New technology combining various types of microscopy with IR and Raman spectroscopy promises unequivocal forensics analyses, not only for fibers, but also for drugs, paint flakes, films, tapes, and other types of trace evidence.

The converging imaging technology is a combination of conventional light microscopy with fluorescence, confocal and infrared spectroscopy, providing chemical signatures along with microscopy images from a wide variety of contrast techniques.

Depending on the system being used, the microscopy component provides context and contrast via techniques ranging from fluorescence and phase to polarized light and DIC. The spectroscopy provides the chemical signature, either in the FT-IR (approximately 2200nm-15,000nm) or Raman (approximately 1000nm-3000nm), all hosted on the same computer.

While both FT-IR and Raman are useful for "fingerprinting" materials comprised from hydrogen, carbon, oxygen, and sulfur, Raman extends the analysis. Both FT-IR and Raman now have well-established histories in materials analysis, a foundation on which forensics can build with confidence. For easy reference, many systems also come with detailed spectral libraries and convenient search engines. Several companies, notably Renishaw (Schaumberg, IL) and SensIR Technologies (Danbury, CT), already have libraries and applications built specifically for forensics.

Spectra-Tech's Continuum FT-IR microscope.

EXTENDING MICROSCOPY INTO THE IR

Glass is the major challenge to converting a regular microscope into one which can collect an IR or Raman signature. Even with quartz optics, a conventional light microscope can only transmit between 220nm (deep UV) and 2200nm (near IR). To overcome this challenge, IR companies have developed special reflected-light Cassegrain objectives. Until recently, aberrations in these lenses have limited their use for imaging. The new technologies have combined conventional optics with Cassegrain optics to improve both microscopy and spectroscopy.

MICROSCOPY WITH A CHEMICAL FINGERPRINT

So much of our world is organic (carbon-based). Microscopy lets us see it and determine its color and shape, whether or not there is adhering material, fibrous structure, or surface information. However, without a chemical fingerprint, it is often difficult to tell the difference between one type of polymer and another, or to differentiate between the coating on a surface and the body of that material.

SensIR's TravelIR on the back of a fire truck—ready to aid first responders

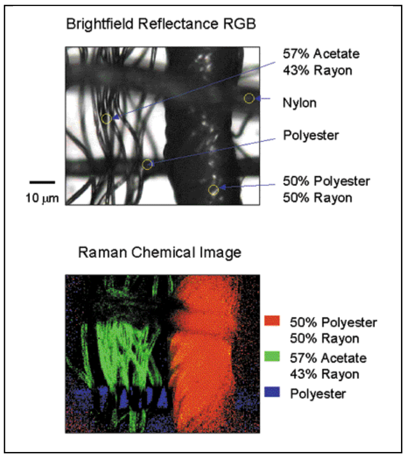
Just last year, Spectra-Tech (Shelton, CT) announced the Continuum, the first truly hybrid FT-IR microscope. While earlier systems have just one conventional objective and used software to change magnification, the Continuum provides options for a variety of objectives on the same turret as its Cassegrain partners. Microscopists will also feel comfortable with its ability to enhance contrast with either DIC or polarized light, both available through conventional or Cassegrain optics. This year's innovation: conventional fluorescence. The output from the Continuum includes both conventional micrographs, usually in digital format, and the FT-IR spectrum from the defined region of interest.

To extend the spectral analysis to a surface, ChemIcon (Pittsburgh, PA) introduced the Falcon. (See *Advanced Imaging* Update, April 2000, pg. 8.) Based on the familiar Olympus BX-50 fitted with fluorescence, the Falcon produces both conventional microscopy and fluorescence images and, using proprietary scanning technology, high-resolution IR maps. (See the example on the facing page.) The Raman images are actually molecular maps which detail morphology, composition, structure, and concentration.

PENETRATING THE DEPTHS: ENTER CONFOCAL

Many samples, though, are not simple monolayers. Combining confocal with Raman expands this type of analysis to multilayer films as well as to materials within materials. The most integrated of the Raman confocals is the research-level system from Jobin Yvon/ISA (JY/ISA; Edison, NJ). Using an Olympus BX-50 as a platform, JY/ISA recently moved to UV optics for improved spatial resolution, stronger Raman signal, and less interference from fluorescence. At PITTCON (New Orleans, LA, March 12-15), they also announced a new external sampling compartment which surrounds the microscope and has attachments for standard analyses on liquid or solid samples without changing configuration.

Jon Noonan, a marketing specialist at JY/ISA, pointed out that, years ago, Raman was used only by Ph.D.s because it used lasers and was difficult to align. Today's third-gen, Windows-controlled system easily scans the *XY* plane. Confocal adds an important *Z* component, allowing the JY/ISA system to choose the precise level at which to take spectra. The system earned high marks in a recent drug bust when it proved that it could identify a cocaine spectrum through a plastic bag. Being able to test the sample without removing it eliminates any potential defense argument about compromising the sample.



Four fibers of similar color and morphology are then RGB color-coded for to distinguish them more easily. (Nylon wasn't coded, so it appears black along with the background.)

Departing from the Chemicon-JY/ISA trend, Renishaw's RM1000B Raman uses an approachable Leica microscope. New optics and the ability to use up to three different lasers extends its range from the UV (229nm) through the near-IR (1100nm).

ON-SITE, IN THE FIELD

New turn: SensIR Technologies has literally taken IR microspectroscopy into the field. As shown in the picture at left, their new TravelIR (pronounced "traveler") is small enough to hit the road. It weighs only 26 pounds and fits in an airplane's overhead luggage compartment. TravelIR uses ATR (attenuated total reflectance) technology—a solid, powder, liquid or paste sample can be placed directly on its diamond sample stage, essentially eliminating sample preparation.

The microscopy image is presented on a high-resolution LCD screen while spectral information is transmitted to a computer through a convenient interface. TravelIR also features a special software suite designed especially for field and/or laboratory narcotics testing. According to Don Feuerstein, SensIR's director of marketing, the system was designed "to allow non-technical personnel to operate the instrument with a minimum of training while ensuring accurate, verifiable results."

READING THE FUTURE

For decades, IR spectroscopy and microscopy have been isolated in two separate universes. The burgeoning field of IR microspectroscopy promises exciting new solutions as these technologies move into forensics. As noted criminologist Henry Lee observed during a presentation at PITTCON: In the 1960s, the way to solve a crime was interrogation, interrogation, confession. In the new millennium, it will be artificial intelligence, expert systems, and evidence linkage. IR microspectroscopy finds itself in a rare position of providing both the expert system and the evidence linkage. By combining visual information from microscopy and chemical identification through IR and Raman, it will serve forensics well. ◆

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