B151 Forensic Paint Analysis With Simultaneous Optical Photothermal Infrared (O-PTIR) and Raman Microspectroscopy

Brooke W. Kammrath, PhD, University of New Haven, West Haven, CT 06516; Eoghan Dillon, PhD, Photothermal Spectroscopy Corp, Santa Barbara, CA 93101; Jay Anderson, BBA, Photothermal Spectroscopy Corp, Santa Barbara, CA 93101; Curtis Marcott, PhD, Light Light Solutions, Seabrook Island, SC 29455; Mustafa Kansiz, PhD, Photothermal Spectroscopy Corp, Santa Barbara, CA 93101; Kaitlin Kruglak, MS, Indianapolis, IN 46240; John A. Reffner, PhD, John Jay College of Criminal Justice, New York, NY 10019*

Learning Overview: After attending this presentation, attendees will understand the advantages of using simultaneous O-PTIR and Raman microspectroscopy for the analysis of automotive paint. In addition, attendees will gain understanding of how O-PTIR works and the benefits it can provide the forensic science community.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating how simultaneous O-PTIR and Raman microspectroscopy can be used to obtain quality chemical information about each of the layers in automotive paint samples non-destructively, rapidly, and with submicron spatial resolutions.

Paint is a common type of trace examined in forensic laboratories because it provides valuable associative information for crimes involving vehicular accidents and home invasions. The complex chemistry of paint can be thoroughly interrogated with vibrational microspectroscopy, with results that are used for its classification and comparison. Traditional IR microspectroscopy is frequently used by forensic paint examiners to identify binders, some pigments, and additives, while Raman microspectroscopy affords the additional ability to identify colored pigments, thus providing complimentary information that adds to the complete chemical characterization of a paint sample. However, both traditional IR and Raman microspectroscopy have limitations. IR microspectroscopy has limited spatial resolution (10–20µm at longer IR wavelengths). Sample preparation for transmission IR microspectroscopy requires skill, is potentially complicated, and is semi-destructive and, while IR analysis with an Attenuated Total Reflection (ATR) objective is an option, it requires intimate contact with the sample (risking cross contamination, sample damage, or even damage to the ATR internal reflection element) and targeting a specific location can be difficult. Fluorescence, which is laser wavelength-dependent and sample specific, is the major limitation of Raman microspectroscopy.

The mIRage+R IR and Raman microscope is a new technology that combines O-PTIR with Raman microspectroscopy to enable the complementary and confirmatory analysis of a sample at the same time, same spot, and same spatial resolution. O-PTIR uses a visible light probe to measure the photothermal response of the absorption of radiation from a pulsed IR laser focused on the sample. The use of visible light allows for non-contact, reflection mode analysis with submicron spatial resolution that is independent of the IR wavelength. Further, analysis is fast (~1 second) and requires little to no sample preparation. The reflection O-PTIR spectra are free of specular and diffuse scatter artifacts and can be directly compared to commercial/custom transmission IR databases. Since this is combined with a Raman spectrometer, IR and Raman spectra are able to be simultaneously and non-destructively collected from a submicron-sized spot in seconds, create a line array in under a minute, and map an area of a sample to create a hyperspectral image within a few minutes to a few hours (depending on the size of the area and desired spatial resolution).

A variety of automotive paints which differ in color (red, blue, and silver), properties (number and chemistry of layers), and production year were collected from auto body shops in the Northeast United States and subsequently analyzed simultaneously with O-PTIR and Raman spectroscopy. For comparison, the samples were also analyzed with stereomicroscopy, brightfield microscopy, polarized light microscopy, traditional ATR IR microspectroscopy, and Raman Microscopy (with a 780nm laser excitation source). O-PTIR plus Raman microspectroscopy provided chemical information (e.g., binder and pigment identification) from all paint layers non-destructively, rapidly, and with minimal sample preparation. The submicron spatial resolution of O-PTIR enabled chemical analysis of paint layers with thicknesses less than 10µm. Hyperspectral imaging with sub-micron spatial resolution revealed chemical mixing between some paint layers at their interface, which has not previously been detected and has the potential to be used for forensic discrimination. This presentation will introduce the forensic science community to the benefits of O-PTIR combined with Raman microspectroscopy for the analysis of automotive paint.

Paint, O-PTIR, Raman

*Presenting Author