D10 Characterization of Condom Lubricant Traces Using Raman Spectroscopy and Raman Chemical Imaging

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The goal of this presentation is to acquaint the forensic community in using Raman Spectroscopy and Raman Chemical Imaging for identifying condom trace evidence.

This presentation will address the use of Raman spectroscopy and Raman chemical imaging as primary methods in identifying condom lubricant traces such as polydimethylsiloxane (PDMS), polyethylene glycol (PEG), nonoxynol-9 (N9), and fine particulates. Chemical imaging possesses the ability to identify these materials in the presence of one another, providing they possess unique Raman spectra, thus minimizing sample preparation that is needed with current methods, namely Fourier Transform-Infrared (FT-IR) analysis. The focus of this experiment lies in applying this methodology to real world samples and demonstrating the use of Raman analysis as a primary analytical technique.

Dispersive Raman spectroscopy in conjunction with wide field Raman Chemical Imaging was used to analyze all samples. PDMS, PEG, N9, and lycopodium spore standards were analyzed, as these are all common lubricant traces. Trojan ultra thin spermicidally lubricated (Carter Wallace, Inc., Carter Products Division) and Plus Beyond Seven SheerIon spermicidally lubricated (Okamoto Industries, Inc.) condoms were also analyzed. Small amounts of raw material from these condoms were examined, and extraction experiments were also carried out according to a protocol set up for FT-IR analysis.

Dispersive analysis of pure components revealed most were Raman accessible. Lycopodium was found to be extremely fluorescent; however, this feature can still be used to characterize it on a Raman system in imaging mode if surface morphology is also considered. All of the other standards exhibited unique Raman spectra, which indicates chemical imaging will be capable of identifying each component. Next efforts focused on differentiating spermicide and lubricant in the presence of one another, namely PDMS and N9, since these are known to be immiscible. Optically the mixture looked no different than the pure components, a transparent liquid, save a few structures that resembled bubbles. Chemical imaging revealed the bubbles were actually emulsions of PDMS in N9.

Analysis of raw material from the Beyond Seven condom optically looked very similar to the mixture of pure components. The lubricant was a transparent liquid with bubbles. In this case, chemical imaging showed the bubbles to be N9 emulsions in PDMS. This is a prime example of how multiple lubricant components can be identified with Raman chemical imaging without first having to extract the sample and isolate the materials.

Analysis of the raw material from the Trojan condom showed predominantly PDMS; however, some weak Raman bands can be seen that are consistent with N9. Dichloromethane and water extracts of the raw material were analyzed. Raman chemical imaging was able to identify PDMS and starch from a dichloromethane extraction. N9 was identified in a water extract as well as calcium carbonate.

This experiment indicates that some of the most common materials found in lubricants are very Raman accessible and can be accurately analyzed by Raman spectroscopy. Furthermore, the analysis can extend to Raman chemical imaging possibly eliminating superfluous sample preparation and multi-instrument analysis.

Condom Lubricants, Raman, Trace Evidence

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