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"Developing techniques for the forensic profiling of improvised explosive devices and 3D-printed firearms"

Locard's Exchange Principle, which posits that "every contact leaves a trace", has long guided the discovery and value of trace physical evidence in the investigation and adjudication of crime. In the modern forensic laboratory, elemental analyses provide a powerful way to identify, characterize, and differentiate recovered trace evidence. As technology and weapon systems evolve, there is an ongoing demand to enhance these techniques to maintain forensic intelligence and support the judicial process. The purpose of this lecture is to share new techniques and strategies for the profiling of two types of trace evidence encountered in Canadian casework.

The first segment of the seminar discusses different approaches for evaluating solders as trace evidence from improvised explosive devices (IEDs). Following the detonation of an IED, electrical components containing solder may be recovered and chemically associated to source materials or tools used in its construction. One technique, based on electrothermal vaporization inductively coupled plasma optical emission spectrometry (ETV-ICPOES), was developed to quantify both trace (impurities and additives) and major (alloy) elements in solders, as well as assess compositional changes during mock IED preparation scenarios. Another approach, developed with the National Forensic Laboratory Services (Trace Evidence Services) of the Royal Canadian Mounted Police (RCMP), combines laser induced breakdown spectroscopy/laser ablation with inductively coupled plasma mass spectrometry (LIBS/LA-ICPMS). This technique allows for rapid screening of solder alloys and achieves quantification *in-situ* with only microscopic destruction to the sample. LIBS/LA-ICPMS is compelling for evidence that is available only in exceedingly small quantities or when exhibits must be preserved (i.e., cannot be digested or destroyed in analysis) for casework and court testimony.

The second segment of the seminar presents preliminary findings from a project focused on characterizing polymer materials used in the fabrication of 3D-printed firearms (3DPFs). This project was initiated within Trace Evidence Services of the RCMP and in collaboration with Laboratoire des Sciences Judiciaires et de Médecine Légale of Montreal. In this project, LIBS is used to characterize various classes and brands of black polymer filaments available on the commercial market (e.g., polylactic acid (PLA), PLA+). Spectral features representative of additives, fillers, or species of the base polymer chain are sufficient to discriminate different filaments and associate traces of 3DPFs to specific filament sources. Outcomes demonstrate that the LIBS method is a quick, effective tool for analyzing black polymers and contributes as a complementary tool to existing spectroscopic methods for 3DPF examination.