Detecting gunshot residue by laser induced breakdown spectroscopy

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Abstract: Laser induced breakdown spectroscopy was used to detect gunshot residue (GSR) on a shooter's hand. Double sided tape pressed to the skin of the shooter was directly analyzed. Characteristic emission lines identified GSR presence.

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1. Introduction

Whenever a gun is fired, gunshot residues (GSR) are expelled from the gun. The origins of GSR can be the primer, propellant, lubricant, bullet, bullet jacket, cartridge case, and gun barrel. The presence of GSR have been used to show that a person had recently fired a gun and patterns of residues have been used to predict firing distances.

The gunshot is initiated when the hammer or striker crushes the primer cup, causing the primer compound lining the inside of the primer cup to ignite. The flame emitted from the primer cup ignites the propellant, which decomposes and drives the bullet down the barrel. Heat generated by the ignition of the primer causes the inorganic compounds in the primer to vaporize, but these vapors condense into droplets. With expansion and cooling on leaving the barrel, many of these droplets freeze in their existing form. GSR from primer contains distinct particles with the characteristic elements of the primer compounds. In addition to the "primer particles," lead particles can arise from lead bullets. GSR also may contain intact, or partially burned, propellant with particle sizes ranging from large visible particles to a fine dust (1-7).

2. Experimental

Samples were obtained by going to a firing range and firing rounds from personal weapons. Samples were obtained by pressing a small (0.5-inch diameter) piece of double sided tape to the hand of the shooter. The tape was mounted in a time-resolved echelle LIBS spectrometer (8) and a single laser pulse was used to vaporize and excite the analyte.

3. Results and discussion

The laser sampled an area approximately 0.3 mm in diameter. Figure 1 shows representative spectra of a blank spectrum, a LIBS spectrum from a sample taken from the shooter's hand after firing weapon, and a spectrum taken from the shooter's hand after washing with soap and water. The blank sample was taken from the same person, but from an area under the sleeve on the opposite arm before firing. Spectral differences between the spectra taken after firing and the blank have been identified. The lines in the blank are due to sodium, calcium, and atmospheric emission. The majority of the lines in the samples after shooting are due to the presence of barium; some lead lines are also present. The time required for the analysis was approximately 2 min.

A single laser shot ablates 0.06% of the surface, leaving the remaining 99.94% of the sample preserved for SEM/EDX analysis. Additional sensitivity may be attained by averaging additional laser pulses at new locations, thus improving the signal-to-noise ratio. The sensitivity appears to be excellent; the shooters were asked to wash their hands carefully using soap and water. The firing hand was re-sampled with a new piece of tape. The results show that gunshot residue can be detected, although the intensity after washing (Figure 1C) drops noticeably (compared to Figure 1B). Samples were also taken after 1, 3, and 10 shots were fired. All spectra are qualitatively identical.

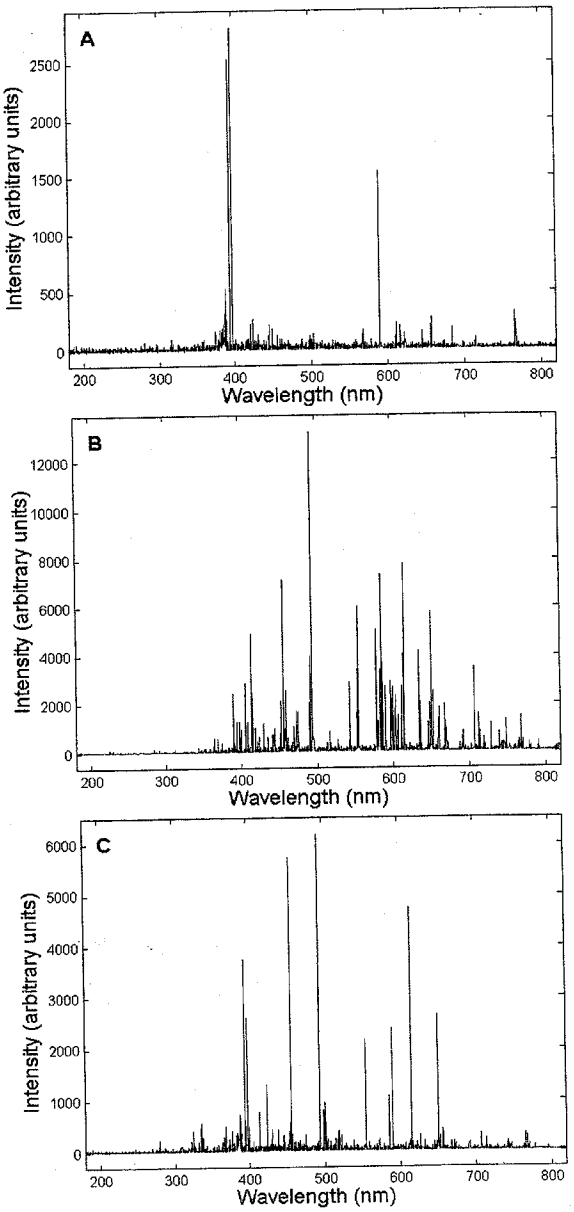

Figure 1. LIBS spectra: (A) blank taken from underneath the shooter's shirt before firing; (B) GSR sampled from shooter's hand after firing weapon; (C) GSR spectra taken from shooter's hand after washing with soap and water.

3. Conclusion

There are two approaches to the interpretation of inorganic GSR results. The first approach is based on finding particles with a "unique composition" that could only have originated from the explosion of a primer. The second approach is based on finding particles that are consistent with the gun and ammunition used. The first approach is limited by a low number of positives in actual casework, and the fact that the use of lead-, antimony- and barium-free primers is on the rise. The second approach is only possible if the gun or ammunition is recovered along with the particles (3).

The results presented here support use of LIBS for detection of gunshot residue. We have successfully used LIBS to detect residue on the hands of a shooter who has fired a weapon. Characteristic emission lines are observed from elements known to be present in GSR, principally barium and lead. The spectra of GSR samples are quite different

from those of the blank. We have also found that, even after washing, detectable amounts of GSR remain. The results reported here are preliminary and further work is in progress to confirm and validate the applicability of these results.

4. References

1. Meng, H. H., Caddy, B. "Gunshot residue analysis-a review," *J. Forensic Sci.* **1997**, *42*, 553-570.
2. Miyauchi, H., Kumihashi, M., Shibayama, T. "The contribution of trace elements from smokeless powder to post firing residues," *J. Forensic Sci.* **1998**, *43*, 90-96.
3. Romolo, F. S., Margot, P. "Identification of gunshot residue: a critical review," *J. Forensic Sci. Int.* **2001**, *119*, 196-211.
4. Wessel, J. E., Jones, P. F., Kwan, Q. Y., Nesbitt, R. S., Rattin, E. J. "Equipment systems improvement program gunshot residue detection," The Aerospace Corporation, USA, 1974.
5. Wolten, G. M., Nesbitt, R.S., Calloway, A.R., Loper, G.L., Jones, P.F. "Particle analysis for the detection of gunshot residue. I: Scanning electron microscopy/energy dispersive X-ray characterization of hand deposits from firing," *J. Forensic Sci.* **1979**, *24*, 409-422.
6. Ward, D. C., "Gunshot residue collection for scanning electron microscopy," *Scanning Electron Microscopy* **1982**, *111*, 1031-1036.
7. Krishman, S. S. "Detection of gunshot residue: present status," in Saferstein, R., Ed., *Forensic Science Handbook*, Prentice-Hall, Inc., NJ, 1982.
8. Goode, S. R., Morgan, S.L., Hoskins, R., Oxsher, A. "Identifying alloys by laser-induced breakdown spectroscopy with a time-resolved high resolution echelle spectrometer," *J. Anal. At. Spectrom.* **2000**, *15*, 1133-1138.