The Use of Laser Induced Breakdown Spectroscopy (LIBS) for the Identification of Bullet Holes

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Introduction

Firearms are used in the majority of murder cases and a large percentage of other violent crimes. For many of the investigations related to these events, a shooting reconstruction is completed using trajectory determination. Without first identifying what is and is not a bullet hole at the scene, the reconstruction will not be as forthcoming. In cases where the hole is not obviously from the passage of a bullet, such as if there is an intermediary target, it could be overlooked and left out of the reconstruction. To date, bullet hole identification has been primarily accomplished through chemical tests, such as the sodium rhodizonate and griess tests. While these tests are efficient in identifying individual chemical elements and functional groups commonly attributed to gunshot residue (GSR) and other components present in the bullet wipe (e.g. copper and nickel from a jacketed bullet), they have significant drawbacks. Some of these include the amount of time required to mix and apply the chemicals, the narrow identification of the chemical components of the suspected bullet hole, and the application of chemicals directly to the item of evidence. With the growing backlog of forensic laboratories, a rapid method for bullet hole identification would be of value for the forensic community. This technique must increase throughput and the level of confirmation while also decreasing the destruction of the evidence in question.

Objectives

- To determine if LIBS is capable of accurately and reliably identifying GSR present on fabrics
- To determine if the type of target material affects the ability of LIBS to detect GSR's characteristic elements
- To determine if the caliber of ammunition affects the ability of LIBS to detect GSR's characteristic elements
- To determine if the angle of impact can be determined through LIBS analysis

Materials and Methods

- 4-inch squares of jersey, sweatshirt, nylon, denim, and fleece were cut and stapled onto cardstock
- Cardstock with fabrics was then placed into a piece of wood with notches cut at 10, 45, and 90 degrees that was mounted onto a tripod
- Cardstock with fabrics were then shot with either .22- or .380-caliber copper-jacketed bullets, with a muzzle-to-target distance of ~ 6 in
- Samples were then analyzed using J200 LIBS
  - 266nm laser; electron capture spectrometer; 100%/*45% energy; 9 50nm shots at 3 Hz in a 2x3 raster; accumulated spectra
- Spectral analysis was completed using Clarity software (Applied Spectra, Inc.), which includes the identification of peaks corresponding to lead, barium, antimony, copper, and nickel
  - The presence of each element in the sample was only considered to be positive if all corresponding peaks were present

* changed for nylon

Results

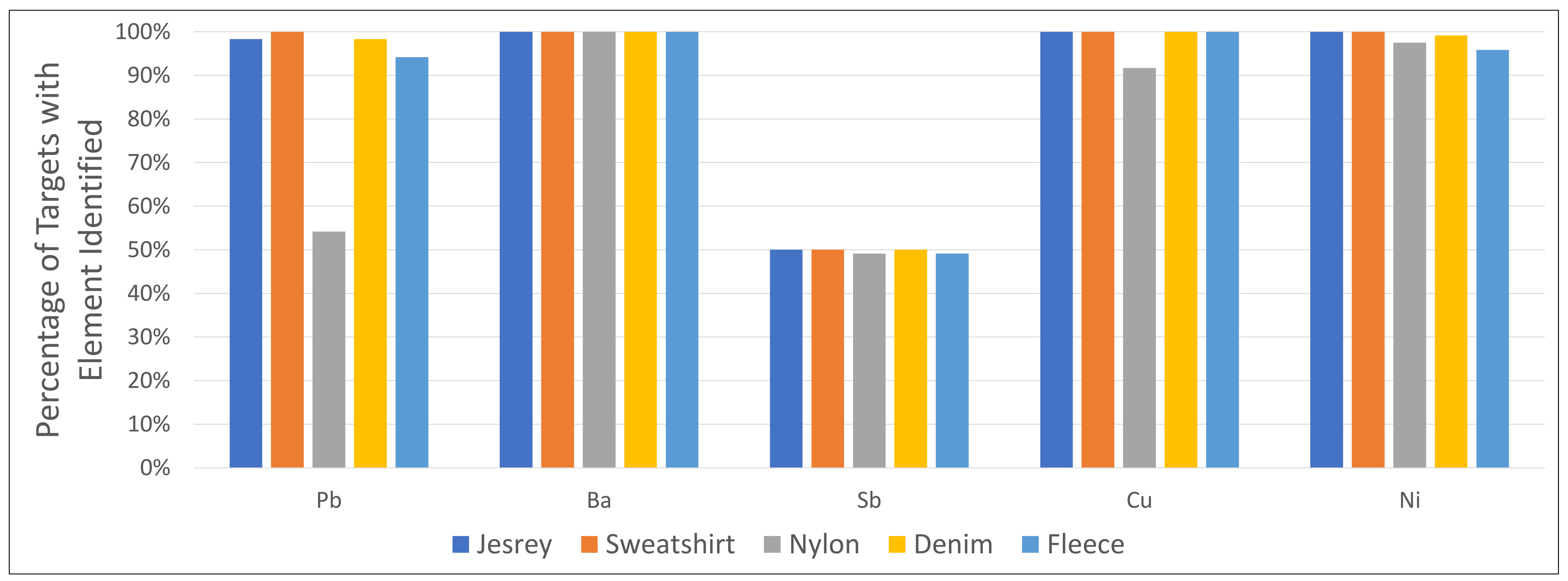

Figure 1: Detection and identification of elements in relation to material

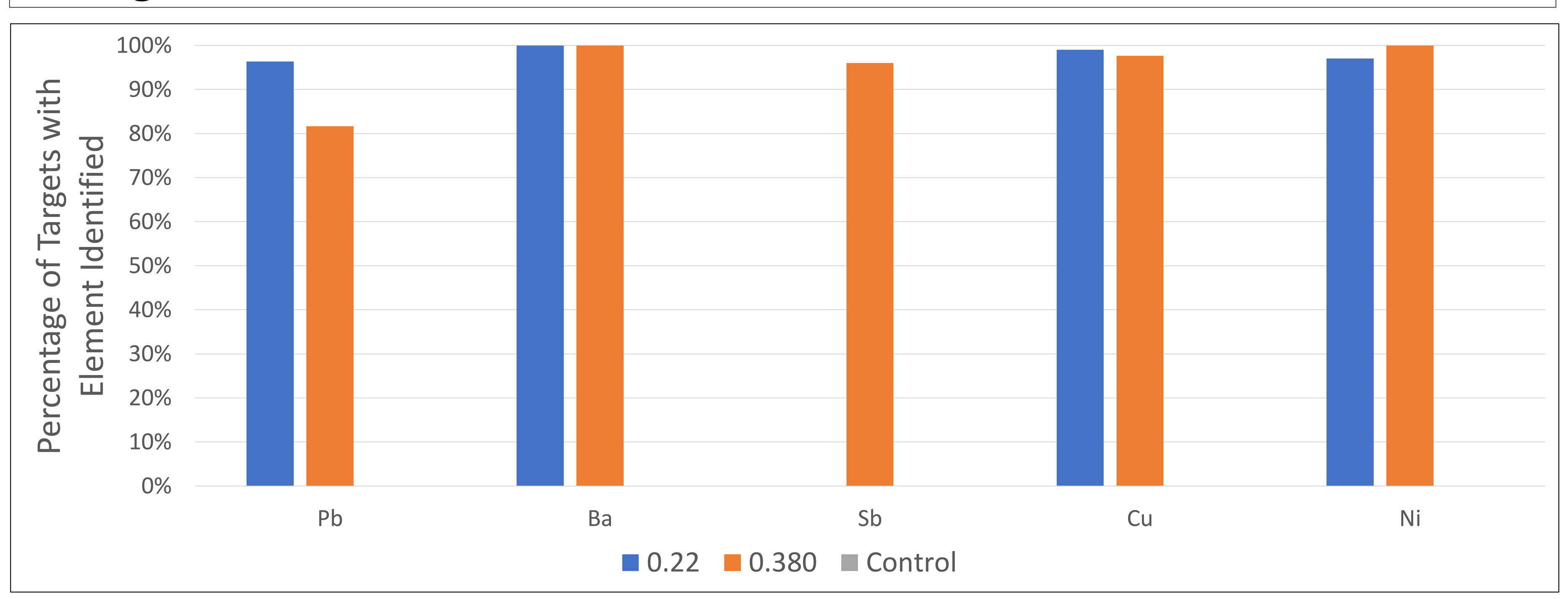

Figure 2: Detection and identification of elements in relation to caliber

Results

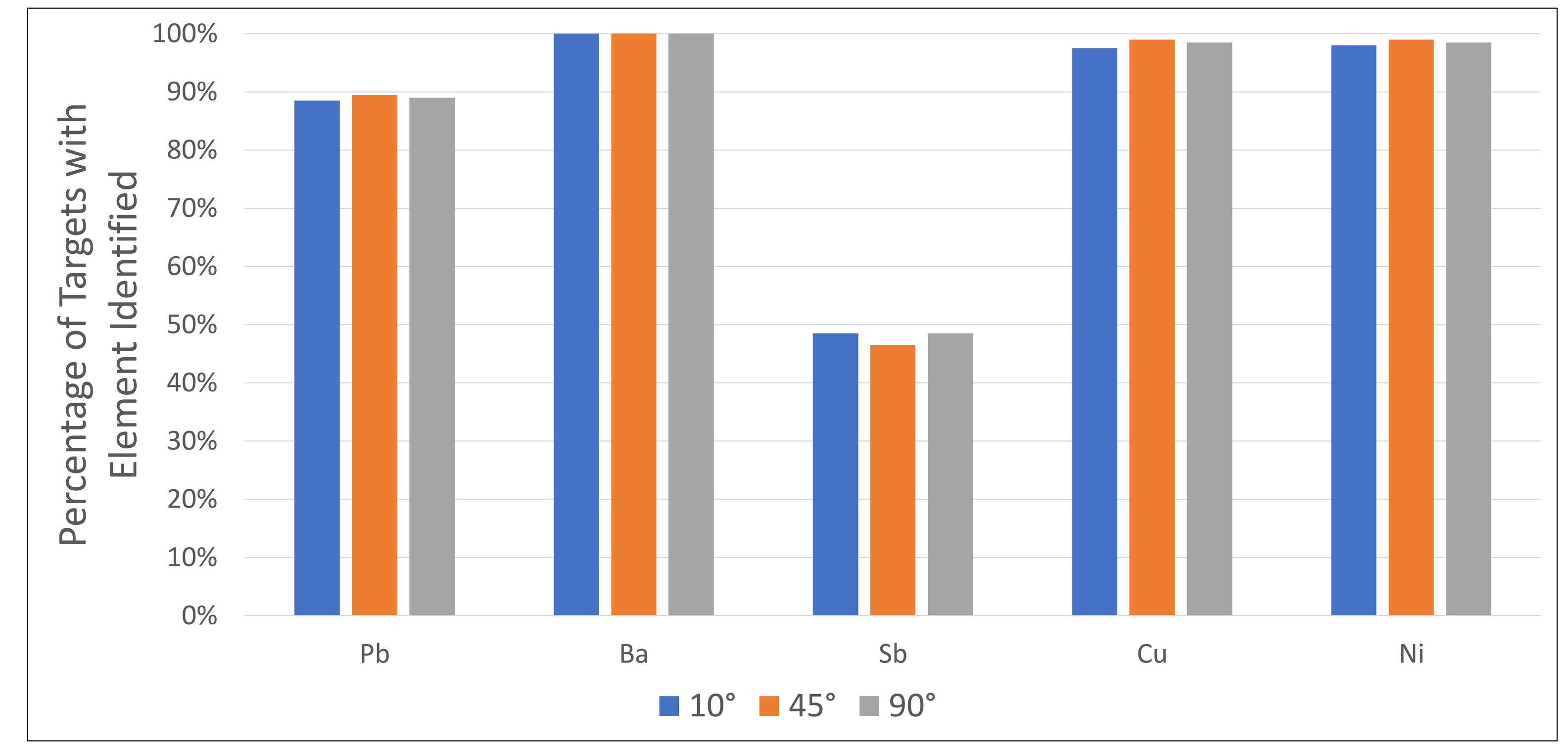

Figure 3: Detection and identification of elements in relation to angle of impact

Ba							Sb
455.4	493.4	553.5	585.3	614.1	649.6	705.9	259.8
Pb					Cu		Ni
220.3	287.3	363.9	368.3	405.7	324.7	327.3	230.3

Figure 4: Table of peaks selected for each element (nm)

Conclusions

- LIBS is an effective method for detecting GSR in a variety of fabrics
- Each fabric, barring nylon, resulted in similar spectra with the chosen instrumental parameters
  - For nylon, the energy of the laser was decreased to accommodate for the melting of the polymer
- The concentration of antimony in the .22 ammunition used was found to be below the limit of detection
- There were no apparent trends in the detection of any of the elements based on angle of impact

Acknowledgements

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