

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

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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.

In this study, laser induced breakdown spectroscopy (LIBS) was evaluated as an elemental analysis method for the identification of bullet wipe. Five common clothing fabrics (t-shirt jersey, sweatshirt jersey, nylon, denim, and fleece) were chosen. These fabrics were shot with two calibers of full copper jacketed ammunition (.22 and .380) at three angles (10°, 45°, and 90°). Five replicates of each sample were analyzed using LIBS from each of the cardinal directions. The resulting bullet holes were analyzed, and the LIBS spectra were examined for the elements lead (Pb), barium (Ba), antimony (Sb), copper (Cu), and nickel (Ni).

Results indicate that this methodology is promising for the identification of these elements using the major non-interfering emission lines for the five elements, which resulted in the analysis of a total of eighteen spectral peaks. Pb peaks were completely absent in the control spectra of the fabrics but were present more than 91.33% of the time in the experimental samples. The Ba peaks were absent from four of the five the controls (it was detected in nylon) and were present in all the experimental samples. Sb had one peak without spectral interferences, which proved useful for the identification of this element in 96.00% of the samples shot with the .380. However, Sb was not detected on the bullet holes produced with the .22. Cu was able to be identified in more than 98.33% and absent in the controls. Ni was able to be identified in 38.50% of the samples compared to all of the controls, excluding nylon, analyzed at one peak on the spectra and was present in 98.50% of the samples compared to absence in the controls at the other peak examined. There were no observable trends in elements detected based on the bullet's incident angle.

Based upon results obtained in this preliminary study, it was concluded that LIBS has the potential to be a useful method for the identification of bullet holes in fabrics. Future research will include examination of additional calibers and types of ammunition, alternative target materials, determining the capability of LIBS for analyzing bullet holes through bunched or layered materials, and the use of LIBS in conjunction with commonly used colorimetric chemical testing.

LIBS, Gunshot Residue, Shooting Reconstruction