GSR Analysis: The Importance of Viable Swab Kits

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Abstract and Background

Since the late 1970s, forensic scientists have been using scanning electron microscopy (SEM) (Figure 1) to analyze gunshot residue particles (GSR) to determine whether an individual or object was in the vicinity of a shooting. GSR particles are from the primer of a gun, and when the gun is fired that primer will also come out of the gun and land on the shooter's hand and objects around them. When an object or a person is swabbed and tested for GSR, forensic scientists are looking for three elements: lead, barium, and antimony (Neely, n.d.). If these elements are found, the object or person is considered positive for GSR and was therefore in the vicinity of a shooting (Neely, n.d.). While lead, barium, and antimony have been the standard for GSR analysis for years, gun primers have recently started to move away from using these heavy metals. As an attempt to expand the library of what is considered a positive GSR test, we began using the Company A two hand-swab Gun Shot Residue kits (Figure 2). After a series of hand swab collections with different caliber guns and SEM analysis, that gave us no results for any kind of GSR, we began to further investigate the possibility of our swab kits being defective.

Introduction and/or Research Question

While searching diligently for an answer on what other elements could also be considered gunshot residue, we ran into a problem of consistently not finding any lead, barium, or antimony on the hand swab samples we tested. We tested several types of guns, some of which we could physically see the gunpowder coming off the gun and around the test subject's hands. After swabbing their hands with the GSR kits from Company A, we would take the samples to a scanning electron microscope and analyze the collection swabs. Instead of finding what literature suggested, the typical lead, barium, and antimony, we would find various other elements that we became hopeful of. However, we slowly started to question the validity of our kits that we were using to collect these samples as we were getting almost the exact same results each time. The SEM could not be giving us these issues, as a side project revealed elements of GSR on another swab kit we were testing at time. We also double-checked our hand-swabbing techniques. The only explanation were the kits from Company A. If these kits are non-viable and being used in real-life cases, that could pose a serious problem to law enforcement and the justice system. So, we decided to put our hypothesis to the test and compare a blank carbon pad from these kits to the results we had collected.

Methods

We began with using the Company A Gun Shot Residue SEM kits. These kits come with two SEM carbon pad discs, one for each hand, that are encased in a plastic container (Figure 2). We began by having a test subject shoot a handgun (between one and twelve shots were fired) and we would then begin taking samples. We did this by putting on gloves and using the carbon pad disc to swab the test subject's hands as directed in the GSR kits (Figure 4). We would then close the carbon pad samples in their respective containers and seal the box shut. Then, we would take these samples to a scanning electron microscope. While wearing gloves, carbon pad discs were removed from the boxes and put onto the SEM stage. The SEM was then booted up and the EDS is inserted to detect the elements on the carbon pads in the SEM. We then took several different sites from each sample and analyzed them for their chemical composition. Pictures from the SEM of the sample and its chemical composition were saved. This process was repeated for every sample. For the comparison of the blank pad to the hand swabs, the 9mm right hand, .357 12 shots right hand, and the rifle 1 shot right hand were chosen (Figure 3). This is because the right hand should show GSR due to that being the dominate hand of our test subjects. These guns are also powerful weapons that should produce GSR.

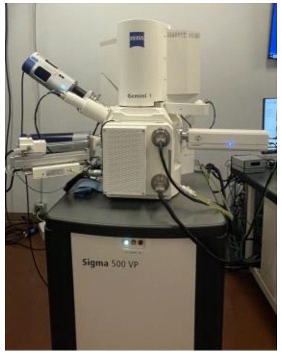

Figure 1. Scanning Electron Microscope (Heinz & Morgan, 2023)

Figure 2. Company A SEM GSR Kit and Carbon Pad (Heinz & Morgan, 2023)

Figure 3. From left to right, the Rifle, 9mm, and 357 Magnum used for testing.(Heinz & Morgan, 2023)

Figure 4. Collecting Samples from Test Subject (Heinz & Morgan, 2023)

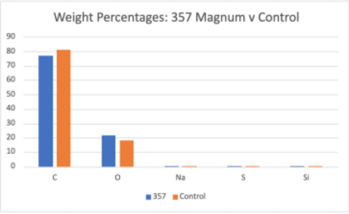

Figure 5. Weight Percentages: 9mm V Control

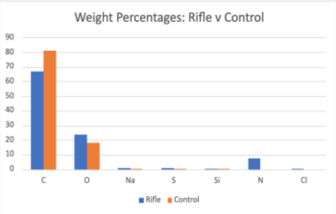

Figure 6. Weight Percentages: Rifle V Control

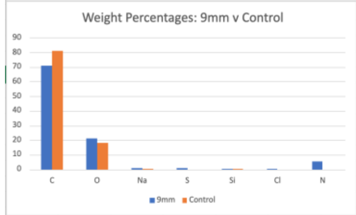

Figure 7. Weight Percentages: 357 Magnum V Control

Figures 5-7. These graphs show the weight percentages of the elements in the blank carbon pad (the control) versus a site from the hand swabs of the different weapons. (Heinz & Morgan, 2023)

Figure 8. SEM Image of the Rifle Hand Swab (Heinz & Morgan, 2023)

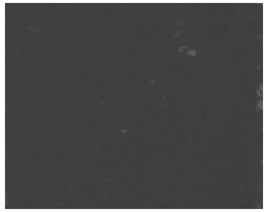

Figure 9. SEM Image of the Blank Hand Swab (Heinz & Morgan, 2023)

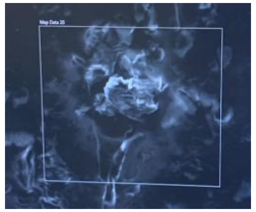

Figure 10. SEM Image of the 9mm (Heinz & Morgan, 2023)

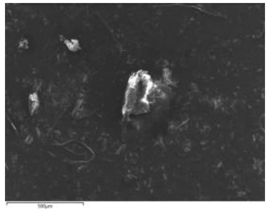

Figure 11. SEM Image of the 357 Magnum (Heinz & Morgan, 2023)

Results and/or Conclusion

After collecting the hand swabs from the volunteers who each used a range of firearms, the samples were taken to the SEM (Figure 1) to be analyzed and have their elemental composition exposed. Figures 8, 10, and 11 are scans from one site on each firearm that were consistent with what GSR may look like. After each site was examined, it became apparent that none of the kits yielded a positive GSR result. According to industry and literature standards, a site may only be considered GSR if it contains trace amounts of barium, lead, and antimony. Carbon and Oxygen were always detected in concentrations of roughly 70% and 20%. This result was expected given that the blank pad (made with a carbon base adhesive), seen in Figure 2, also contained carbon and oxygen but in lesser amounts. Acting as our control, elements such as sodium, silicon, and sulfur were identified on the blank pad as well. This means that if detected on a hand swab, these elements could not be confirmed as "new GSR elements" and were thus ignored as either an impurity or byproduct of the carbon pads used. Given that carbon and oxygen were consistently found in high amounts, it left approximately 10% in each hand swab for additional elements. Upon final examination, after all the hand swabs were collected, no amounts of barium, lead, or antimony were discovered. These findings raised concern given that the hand swabs had all been taken from individuals whom we saw fire guns. All results from this investigation were therefore denoted as false negatives. After that, the investigation with Company A's kits was halted and new procedures and methods were adapted to better answer the original aim of the study. The most disturbing part of our findings is the fact that Company A's products are supposedly permissible in a court of law to determine if someone has or has not been in the vicinity of a fired weapon. An inaccurate answer to this question could unlawfully tilt the scales of justice and either exonerate a guilty party or condemn an innocent one. After interpreting the results of our findings, it becomes clear that the carbon pads themselves were contaminated from the beginning with sodium, sulfur, and silicon, skewing our results. Could it be that the GSR collection kits from Company A are fundamentally flawed in their function, or did we happen to receive a bad batch of kits? Further testing of Company A's kits would have to be done to determine whether our contaminated kits and results are the norm or not.

Future Work

1. Further investigate Company A's swab kits to see if all their SEM kits have this issue or only certain ones do.
2. Investigate other SEM GSR swab kits to see how they compare to Company A's kit.
3. Consider the possibility of engineering a contamination-free GSR SEM kit.

References and/or Acknowledgments

Dr. Issacs from the department of biology & chemistry for generously allowing us to make valuable use of his time and property while collecting GSR Samples.

Dr. Atwater from the school of engineering who patiently taught us how to use an SEM and guided us along the way when examining samples.

The ASSURE 2023 Summer Research Program for giving us the opportunity to research this topic and gain valuable experience as scientists.

References

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Heinz, B., & Morgan, A. (2023) [unpublished graphs of varying weight percentages; firearms vs. control samples]
Heinz, B., & Morgan, A. (2023) [unpublished images from Liberty University's scanning electron microscope]