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A Validation Study of BlueView™ Gunpowder Particle Testing Kit

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A Validation Study of BlueView™ Gunpowder Particle Testing Kit

by

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Abstract

The examination of gunshot residue is often an integral part of evidence processing. The aim of this preliminary study is to validate the use of the BlueView Gunshot Particle Test Kit in the field. This was done by comparing the results of the presumptive tests using the BlueView Gunshot Particle Test Kit to confirmatory test results using a scanning electron microscope. This study used both collection techniques to collect samples for presumptive tests and confirmatory tests. Gunshot residue samples were collected from the hands after a series of guns were fired, and positive results were obtained from the presumptive and confirmatory tests. The results of this study conclude that BlueView Gunshot Particle Test Kit could possibly be an effective method for conducting presumptive tests in the field for gunshot residue particles. This pilot study was conducted under almost perfect conditions, so further analyses need to be conducted to test additional variables.

Keywords: Gunshot Residue, Validation, Scanning Electron Microscope, Colorimetric Test, Presumptive Test, Confirmatory Test

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List of Abbreviations

GSR	Gunshot Residue

Chapter I: Introduction

The current standard operating procedure for collecting and analyzing gunshot residue from a suspect, victim, or crime scene requires utilizing a gunshot residue field kit and sending the kit to a crime lab to be examined with a scanning electron microscope. The scanning electron microscope will scan for gunshot residue particles to confirm the presence of gunshot residue. Unfortunately, this test does not always work because it is not extremely sensitive. For example, if shooter washes his or her hands after firing a weapon, this test will usually not be able to detect the presence of gunshot residue (Saferstein. 2011). However, new studies are being conducted with chemical reagents that cause a colorimetric change to indicate the presence of gunshot residue. This method could lead to the implementation of a presumptive test for the presence of gunshot residue.

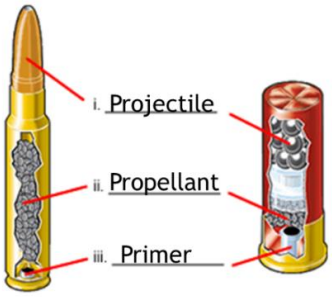
The purpose of this thesis was to compare different reagents to determine which one is the best at detecting the presence of gunshot residue. After a person fired a weapon, a reagent was applied to his or her hands and face to test for the presence of gunshot residue. This method was used with multiple guns and tested against multiple variables. The research hypothesis was that the BlueView™ test kit would work better than the Diphenylamine reagent. This is important because if this led to the addition of a presumptive test to the standard operating procedure, then it may lower laboratory costs and increase the chances of proving a perpetrator fired a weapon.

Chapter II: Literature Review

What is gunshot residue?

There are many components in a bullet that work together to create the chemical reaction necessary to move the bullet down the barrel of a gun. Once the trigger is pulled, the force of the firing pin hitting the primer causes the primer to combust. Upon combustion, the propellant is ignited and the gas produced from the ignition ejects the projectile down the barrel and out of the gun (Heard, 2008). The process of pulling the trigger to the discharging of the projectile from the weapon takes less than a second. When a person fires a firearm, some of the microscopic particles that make up the primer and propellant will be expelled as the ammunition is propelled down the barrel of a weapon. These microscopic particles are known as gunshot residue (Heard 2008).

Gunpowder, or propellant, has been modified and redesigned throughout the years. The black powder used as primer and propellant centuries ago has been revolutionized into primer made of lead styphnate, antimony, and barium nitrate (Saferstein 2011). Propellant has been updated to be made primarily of nitrocellulose, lead, antimony, and barium. When a gun is fired and these elements explode out, some of the particles will coat the shooter's hands (Heard, 2008). Figure 1 illustrates the anatomy of a bullet and a shotgun shell (The "Annies" 2016).



a *b*

A diagram of the components of two different types of ammunition (a) is a bullet and (b) is a shotgun shell.

Figure 1

How is Gunshot Residue Distributed?

Most gunshot residue will be found on the firing hand; however, it usually only covers a portion of the hand because of the way a gun is held. The section of the hand where gunshot residue can usually be found includes half of the back of the hand; the middle finger, forefinger, and thumb; and the center of the palm of the hand (Saferstein, 2011). Despite the fact that the highest concentrations of gunshot residue are found on the back of the hand and the palms, gunshot residue can be found in other places. Gunshot residue can be found in between the thumb and forefinger, the wrists, and even the non-firing hand. This is due to environmental conditions such as wind, the way an individual holds the firearm, and the type of gun being fired (Walker, 2002). Figure 2 is an illustration of where the best places to test for gunshot residue are located (Heard, 2008).

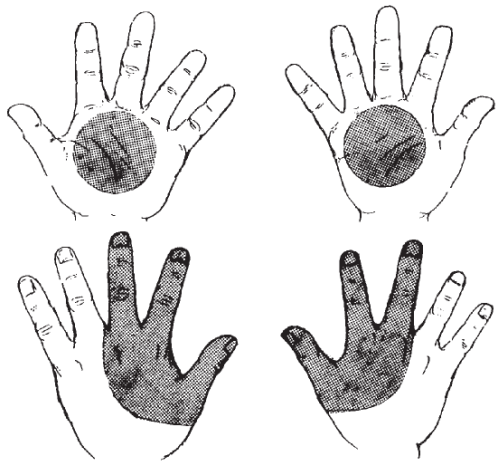


Diagram of where highest concentration of gunshot residue is most likely to be.

Figure 2

How do different firearms affect gunshot residue distribution?

While the elements that make up gunshot residue are important, the type of weapon being shot is equally important. The type of firearm being used can restrict or increase the amount of gunshot residue that is blown out of the weapon. For example, a person shooting a revolver will likely have more gunshot residue on his or her hands after one shot than a person who fired a shotgun. The chamber of the revolver is exposed and the space between the back of the barrel and the beginning of the cylinder can allow for more particles to escape. The structure of a gun is a determining factor in how much gunshot residue will land on the shooter's hands (Heard, 2008).

Semi-automatic weapons are self-loading firearms that do not require the shooter to manually load ammunition into the gun for every shot. One round of ammunition must be loaded manually by cocking the gun, and a mechanism inside the gun will automatically load the next bullet and discharge the shell casing through the ejection port after each time the trigger is pulled. In semi-automatic guns, gunshot residue particles can

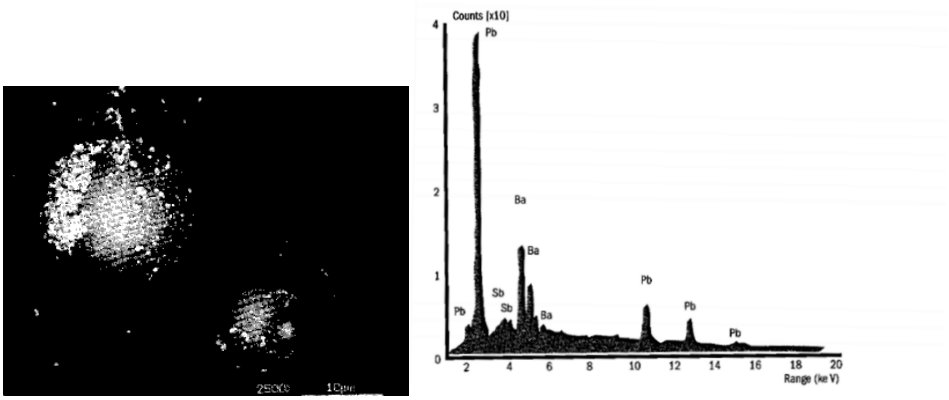
exit through the ejection ports- the opening on a firearm where the shell casing is ejected. This type of gun will allow for more gunshot residue particles to coat the shooter's hands (Heard, 2008).

In some guns, however, much of the gunshot residue is fired through the muzzle and away from the shooter, and little to no gunshot residue will be present on the shooter's hands. Most shotguns are good examples of guns that will expel little to no gunshot residue. Unless a shotgun is semi-automatic, the shooter must use the action to dispel the shell casing in the chamber of the gun. The three most common actions for shotguns are break action, bolt action, and pump action. In a break action shotgun, the gun will literally break open to dispel the shell casing. Bolt action shotguns use a bolt mechanism that will slide the chamber and cause the extractor to pull the shell casing out of the chamber. Pump action guns work similarly to rifles in that they require the shooter to push the action forward then pull backward to eject the shell casing through the ejection port. Even though bolt and pump action shotguns both have ejection ports, they are not always semi-automatic. In these guns, gunshot residue will not be deposited onto the hands unless the shooter opens the action immediately after firing the weapon. If they do open the action directly after shooting, the gunshot residue will escape from wherever the action is and land on the shooter's hands (Heard, 2008).

Current Testing Methods

Today, the most common technique used for detecting gunshot residue requires the field investigator to use an adhesive stub to pick up microscopic gunshot residue particles from the suspect's hands. Primer residue kits are made by various companies, and can be easily purchased online. Once the gunshot residue has been collected from the

hands, the adhesive stubs are loaded into a scanning electron microscope. With this microscope, the individual particles can be detected. Then, a reading in the form of a spectrum is given that specifies the amount of gunshot residue particles present. The scanning electron microscope works by sorting particles by shape, size, and chemical composition. This method of classification allows the scanning electron microscope to be highly specific. Unfortunately, this testing method requires disproportionate operator time compared to other tests (Saferstein 2011). Figure 3 shows the presence of gunshot residue particles and the results given by the scanning electron microscope (Saferstein 2011).



a *b*

The example results of gunshot residue found by a scanning electron microscope (a) is a picture of gunshot residue particles (b) is a measurement of the amount of gunshot residue particles present.

Figure 3

Another method of testing is known as swabbing. This method uses cotton dampened with 5 percent nitric acid to remove any particles of gunshot residue on the hands. The back of the hands and the front of the hands are swabbed separately. Using Atomic Absorption Analysis, the swabs plus a control are analyzed. The elements that are

present in gunshot residue occur in very small amounts, so the test must be highly sensitive. Atomic Absorption Analysis uses light wavelengths to detect particles down to parts per billion of a gram. A high level of barium and antimony indicate the presence of gunshot residue particles. However, this method of testing often proves inconclusive- even in cases where there was strong suspicion of an individual firing a gun. This is attributed to the fact that primer often does not remain on the hands for a long period of time. If a suspect washed their hands or brushed them off, it is likely that the Atomic Absorption Analysis will not yield a conclusive result (Saferstein 2011).

BlueView™ Gunpowder Particle Test Kit

The BlueView™ test kit is a gunshot residue field test kit developed by SIRCHIE®. This test reacts with the nitrates found in gunshot residue and is fast and reliable. The BlueView™ test kit is user friendly and does not require any specialized training to use. The test consists of adhesive strips that must be applied to the backs of the hands and palms after shooting a handgun and the backs of the hands, palms, webs of fingers, cheeks, and shoulder area of the shooter's clothing after shooting a rifle or shotgun. Once the gunshot particles have been removed with the adhesive, the adhesive is placed into a sealed pouch that contains the reagent. The container of the reagent must be broken, and if gunshot residue is present, blue specks should appear in approximately three to six minutes. The reagent contains sulfuric acid which is very corrosive, so the individual performing the test must be very cautious. Unfortunately, this test would only serve as a presumptive test. The residue left from the presumptive test would need to be sent to the crime lab to be tested with the scanning electron microscope in order for the presence of gunshot residue to be confirmed. Despite the fact that this testing method is

only a presumptive test, it could improve the efficacy of gunshot residue testing because the testing could be performed in the field. (SIRCHIE® 2016).

Gunshot residue can be a vital piece of evidence in a forensic investigation. It could be the difference between proving guilt or innocence of a given suspect, or it could help investigators put all the pieces of a case together. Improvements are being made in detecting gunshot residue, but there is still a long way to go until there is a reliable method of testing for gunshot residue.

Chapter III: Methodology

Materials

For this study, the BlueView™ Gunpowder Particle Test Kit, a two-stub gunshot residue collection kit, and a scanning electron microscope was used to collect and analyze samples. The BlueView™ test kit contained ten testing pouches that contain a crushable ampoule of reagent and an adhesive particle collection lifter. This test was purchased online from the SIRCHIE® website. The two-stub collection kit was also purchased from the SIRCHIE® website. Each kit contained two stubs that have an adhesive to collect gunpowder particles, and the stubs were analyzed using a scanning electron microscope.

Methods

At a shooting range, four guns were used to create a range of gunshot residue amounts. An enhanced concealed carry instructor supervised as a .38 single action revolver, a Luger 9 mm, a bolt action Remington 270 rifle, and a Remington 410 gauge shot gun were shot. Protective eye and ear wear were also worn. After each shot was fired, the hands and webs of the fingers were swabbed for gunshot residue. When a rifle or shotgun were fired, then the cheeks and shoulder area were swabbed as well. After swabbing the appropriate areas, a reagent was used to test for the presence of gunshot residue. Since the reagent contained sulfuric acid, gloves were worn when using the BlueView™ reagent. Once the allotted time had passed for results to appear, a Fujifilm-finepix HS25EXR camera was used to document the test results in addition to the notes recorded.

The first phase tested the sensitivity of the tests by seeing if washing the hands after firing the gun affected the results. There were four tests conducted for each gun that

was fired; the first test was a pre-test to check for anything that could cause a false positive, the second test was done after firing the weapon, the third was a pre-test to test for false positives, and the fourth was done after firing the weapon and washing the hands. The second phase tested whether enough residue for a confirmatory test could be collected after performing the presumptive test. There were only two tests conducted during this phase. The first test was a pre-test to check for false positives, and the second test was used to check for residue after firing a gun. Then, a two-stub gunshot residue collection kit was used to collect a sample that was run through a scanning electron microscope to confirm the presence of gunshot residue.

The data collection was done as firing ranges and licensed instructors were available. The collection for each test was done in one day due to the rapid nature of the test kits. The confirmatory tests were performed at the Mississippi Forensic Laboratory in Pearl, Mississippi and approximately one week was needed to obtain the results from the tests. Once all the data collection was done, it took no more than one to two days to organize the results in a cohesive manner. Data collection began in Fall of 2017 and ended in the Spring of 2018.

Chapter IV: Results

Gunshot residue was collected after firing a series of four guns using two collection methods. The BlueView Gunshot Particle Test Kit was used to check the palms and the backs of the hands for false positives and to perform the presumptive tests for gunshot residue before and after washing hands. The second collection method utilized a two-stub gunshot residue collection kit to obtain samples that would be analyzed with a scanning electron microscope. The results from the presumptive tests were recorded and photographed. The samples used for the confirmatory test were analyzed using a scanning electron microscope and were categorized as positive or negative for gunshot residue based on the number of indicative particles identified on each stub. Indicative particles are the metal particles lead, barium and antimony that comprise gunshot residue. Tables 1 and 2 reflect the results from the presumptive tests, and Table 3 the number of indicative particles detected on each stub.

Table 1: Results Obtained Using the BlueView™ GSR Kit After Washing Hands

Test Performed	270 Bolt Action Rifle	.38 Single Action Revolver	Luger 9mm	410 Gauge Shot Gun
False Positive	Negative	Negative	Negative	Negative
GSR Collection	Negative	Positive	Positive	Positive
False Positive	Negative	Negative	Negative	Negative
GSR Collection After Washing Hands	Negative	Positive	Negative	Positive

Table 2: Results Obtained Using BlueView™ GSR Kit

Test Performed	270 Bolt Action Rifle	.38 Single Action Revolver	Luger 9mm	410 Gauge Shot Gun
False Positive	Negative	Negative	Negative	Negative
GSR Collection	Positive	Positive	Positive	Positive

Table 3: Scanning Electron Microscope Results

Stub 1*	**121 GSR**
Stub 2*	163 GSR
Stub 3*	40 GSR
Stub 4*	46 GSR
Stub 5	Indicative- Lead and Antimony
Stub 6	Indicative-Lead and Antimony
Stub 7*	57 GSR
Stub 8*	132 GSR

**Marked stubs also had indicative particles. (Lead, Antimony; Lead, Barium; Barium, Antimony)*

Table 1 indicates that the BlueView™ Gunshot Particle Test Kit is sensitive enough to indicate the presence of gunshot residue even after the hands are washed. Table 2 only shows results immediately after firing weapon because samples for confirmatory tests were collected immediately following the presumptive test. Table 3 confirms the presence of gunshot residue on each stub. Two stubs were used for each gun fired. One stub was used to collect a sample from the left, and one stub was used to collect a sample from the right hand. Stubs 5 and 6 only had two of three metals found in

gunshot residue; however, those stubs were still considered positive for residue due to the variance in gunpowder from one ammunition manufacturer to another.

It should be noted that the collection and analysis of the gunshot residue was conducted under optimal conditions. The presumptive tests and the collection of the samples for the confirmatory tests were conducted immediately after firing a weapon. However, the BlueView™ Gunshot Particle Test Kit proved to be an effective method for presumptively identifying gunshot residue on the hands. In addition, there was still enough gunshot residue left on the hands after performing a presumptive test to obtain a sufficient sample for a confirmatory test.

Chapter V: Conclusion

The results of this study indicate that the BlueView™ Gunshot Particle Collection Kit could potentially be an efficient method of performing a presumptive test for gunshot residue in the field. Since this a pilot study, there were no prior studies the results could be compared to. Despite the lack of prior studies or literature, the results still supported that the BlueView™ Gunshot Particle Test Kit is a fast, reliable presumptive test that can detect trace amounts of gunshot residue. However, the collection methods were performed under almost perfect conditions, and conditions in actual forensic investigations may not be as optimal.

Some limitations became evident throughout this study that could have affected the results. The sample collected for the confirmatory test using the scanning electron microscope was collected immediately following the presumptive test. In most forensic investigations the timeline of collection would most likely be more drawn out, so the results from those investigation would likely not be ideal. Also, the BlueView™ Gunshot Particle Test Kit detects nitrates. Consequently, there are many possible sources for false positives such as car exhaust, fertilizer, or cured meats. Results could be improved by conducting further studies that examine whether these factors would affect results.

Since this project was a pilot study in gunshot residue presumptive testing in the field, additional studies should be done to determine the limitations and benefits of the BlueView™ Gunshot Particle Test Kit. Some suggestions include investigating possible sources of false positives, comparing the BlueView™ Gunshot Particle Test Kit to other presumptive gunshot residue test kits, and collecting samples in conditions more comparable to the conditions that would be encountered in actual investigations. This list

of possible avenues of research is not exhaustive since the BlueView™ Gunshot Particle Test Kit is somewhat new. As more studies are conducted using the BlueView™ Gunshot Particle Test Kit, additional research possibilities may become evident that could provide more information regarding the use of the kit in forensic investigations.

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Appendix

Sample Pictures of Results from BlueView™ Gunshot Particle Test Kit

Positive Result: .38 Revolver Using BlueView™ Gunshot Particle Test Kit

Negative Result: False Positive Using BlueView™ Gunshot Particle Test Kit