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A COMPARATIVE STUDY OF COLOUR TESTS FOR GUNSHOT RESIDUE

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Abstract

Colour test is one of the most commonly used tests at a crime scene for Gunshot Residue (GSR). The objective of this study is to compare two types of color tests under various conditions. The color tests that were used for the experiment include Griess's test and Diphenylamine test. In this research, sponges were used to collect GSR on a non-porous surface, whereas cotton was used for porous surfaces. GSR particles were collected from glass and a piece of cotton cloth which are the surfaces commonly found at a crime scene. Moistened sponge is used to swab the GSR from the surface of glass. For the GSR landed on a piece of cloth or non-porous surface, the cloth was soaked in water. Then, the water was tested with spot tests. In this research, the distance between the surfaces and the gun, the time interval between shooting and sample collection, the type of gun and the amount of gun powder were varied. The results indicated that for porous surfaces, the GSR could only be detected using Griess's test. The best distance for collecting the GSR is between 60 and 100 cm. The higher the amount of gun powder particles in the bullet, the better the chance to detect the GSR. As for the time interval, there is a higher possibility of detection if the samples were collected right away. The present results also indicate that after a day, the GSR can be detected much easier on a non-porous surface than on a porous one.

Keyword: Gunshot Residue, Griess's test, Diphenylamine test, Ammunition, spot

Introduction

In cases involving firearms, one of the most important evidence left at a crime scene is gunshot residue (GSR). GSR can be used to estimate the shooting distance, distinguish bullet holes, and identify whether or not a person has used a firearm. GSR can be divided into two categories: organic and inorganic compounds. The major component of GSR is organic (1, 2). In the earlier days, the detection of GSR was mainly focused on the recovery and identification of organic components which were nitrites and nitrates. GSR can be detected using Scanning Electron Microscope, Atomic Absorption, and Ion Chromatography, however at a crime scene these instrument are not available and expensive. This is why a presumptive test has to be done before collecting the evidence. At crime scene, color test is the best solution for GSR screening test since it is inexpensive, convenient, reliable, and reproducible. In this research, two types of color tests, Griess's test and Diphenylamine test, were examined in order to determine their efficiency in various situations.

Methodology

Spot Tests

Griess's test is one of the spot tests that are used in the research. It is used to test for nitrites. Griess's Test uses a solution of 4-aminobenzene sulfonic acid, acetic acid, N-(1-napthyl) ethylenediamine and methanol. As the reagent mixed with the sample containing nitrite, it will react with sulfanilic acid to form a diazonium compound which then couples with N-(1-napthyl) ethylenediamine to form a pink color (Fig.1b). The more intense the pink color, the more nitrite is present in the sample. The Griess's solution consists of 2 reagents. The first is sufanilic acid (1 g in 100 mL of 30% acetic acid) and the second reagent is N-(1-napthyl) ethylenediamine (0.5 g in 100

mL of methanol). Griess's test is done by first adding a few drops of the first reagent to the sample followed by a few drops of the second reagent (2). The other color test used in this research is Diphenylamine test (3). This spot test is used to test for the nitrate ion. Diphenylamine test has many false positives since most oxidizing agents other than nitrate ion can rapidly oxidize diphenylamine in sulfuric acid solution to the blue quinoidal compound (Fig.1a). Diphenylamine reagent is prepared by dissolving 1 g of DPA in 100 mL of concentrated sulfuric acid.

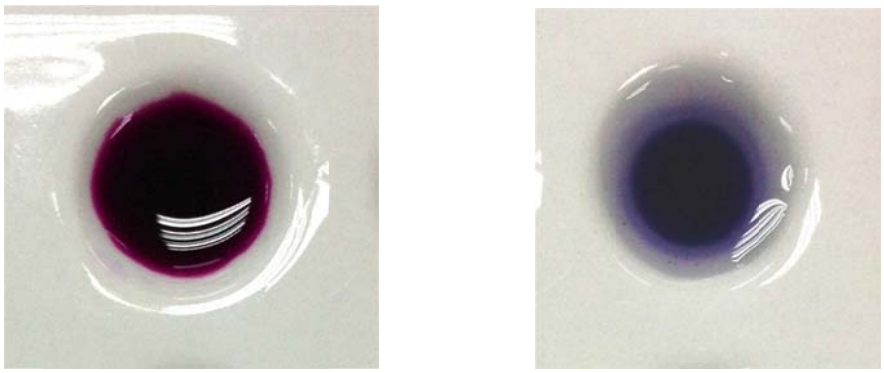

Fig1. a) DPA tested with 10 ppm of $NaNO_2$ (right). b) Griess's tested with 10 ppm of $NaNO_2$ (left)

Firearms

Two guns were used which were a revolver and semi-automatic pistol. The revolver used was a S&W Revolver caliber .357 MAGNUM MODEL 686-3 (Fig 2a), whereas the semi-automatic gun used was a CZ 75BD police caliber 9MM LUGER (Fig 2b). These types of guns represent the guns commonly found at a crime scene.

Fig 2. a) S&W Revolver caliber .357 MAGNUM MODEL 686-3 (left) b) CZ 75BD police caliber 9MM LUGER (right)

Sample Collection

The surfaces GSR was collected from were a glass plate and a piece of cotton cloth which represented the surfaces found at the crime scene. In the preliminary test, sponge (4.0 cm x 2.0 cm x 0.5 cm) was used to swab both surfaces using 200 µL of distilled water. The sponge gave a good positive result with the glass plate, whereas on a cloth the sponge produced negative result. From this result, the cloth containing the GSR was then tested by soaking in 50 mL of distilled water for at least an hour before using 200 µL of the water to test for the GSR. The positive result could then be observed clearly. These were the methods used in GSR collection in this research.

Factors affecting the tests

The varied factors were the distance between the gun barrel (5) and the surfaces, the time interval between the shooting and collection, and the number of bullet fired (4). The GSR were collected from 3 distances to determine the best distance for GSR collection. The amount of bullet fire will be tested for how many bullets have to be fire before GSR could detected. The time space between the shooting and collection of GSR will be varied from testing for GSR right away after the shooting, 12 hours after the shoot and 1 day after the shooting.

Results

Number of shots fired

In this experiment, the number of shots needed to be fired before able to detect for GSR were tested. One, three, and five bullets were fired. The cotton cloth and glass plate were placed at distances of 10, 60 and 100 cm away from the gun barrel. According to the results, the glass plates using both spot tests with only one bullet fired at 10 cm, 2 out of 3 repeats showed a negative result for the semi-automatic pistol. As for the revolver, no positive results were obtained. But for the 60 and 100 cm using both guns, at least 2 out of 3 positives were obtained in each test. For 3 and 5 bullets fired by both guns and both spot tests, most of the test gave a positive result in all repeat of every distance, except for a few. Results are shown in Table 1.

Table 1. Results of Sample Obtained from a Glass plate with 1, 3, and 5 bullets shot.

Glass once	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10 m	- - -	- - -	+ - -	+ - -
60 m	+ - +	+ - +	+ + +	+ + -
100 m	+ + +	+ + -	+ + -	+ + -
Glass 3 times	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10 m	+ - +	+ - +	+ - +	+ - +
60 m	+ + +	+ - +	+ + +	+ + +
100 m	+ + +	+ + +	+ + +	+ + +
Glass 5 times	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10 m	+ + +	+ + +	+ + +	+ - +
60 m	+ - +	+ + +	+ + +	+ + -
100 m	+ + +	+ + +	+ + -	+ + +

The cotton cloth was soaked in water for at least one hour before testing for GSR. For both the revolver and semi-automatic pistol, the DPA reagent gave negative results at all distances, regardless of the number of shots fired. For Griess's test, the semi-automatic pistol gave negative results at all distances with a bullet shot once. When 3 and 5 bullets were shot, however, the Griess's test showed a positive result in all distances except for 5 shots at 10 cm. For the revolver, using Griess's test gave a positive result for 3 and 5 shots at almost all distances except for 3 shots at 10 cm. Whereas in the experiment with 1 bullet shot at 10 and 60 cm, there were 2 out of 3 negative results; at 100 cm 2 out of 3 positive results were obtained. Results are shown in Table 2.

Table 2. Results of Sample Obtained from a Piece of Cotton with 1, 3, and 5 shots

Cotton Once	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	- - -	- + -	- - -	- - -
60	- - -	- + -	- - -	- + -
100	- - -	+ + -	- - -	+ - -
3 times	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	- - -	- - +	- - -	- + +
60	- - -	+ + +	- - -	+ + +
100	- - -	+ + +	- - -	+ + +
5 times	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	- - -	+ - +	- - -	- - -
60	- - -	+ + +	- - -	+ + +
100	- - -	+ + +	- - -	+ + +

Times interval between Shooting and Collection

In this experiment 3 bullets were fired and the GSR collected at various time intervals. According to the results, for both spot tests on the glass plate when the samples were collected immediately after the shooting, at all distances most results were positive for both guns. As for samples collected 12 hours after the shooting, the revolver gave almost all positive results at all distances for both spot tests except for the DPA test at 10 cm for which the results were 2 of 3 negative results. For the semi-automatic pistol at 10 cm both spot tests gave 2 of 3 negative results and at 60 and 100 cm, 2 out of 3 positive results. For samples left one day after the shooting, 2 out of 3 result were negative at all distances using both spot tests except at the distance of 60 cm where 2 results out of 3 were positive. For the revolver at 10 cm both spot tests gave 2 negative results out of 3; at 60 and 100 cm both spot tests gave 2 positive results out of 3 tests. Results are shown in Table 3.

Table 3. Results of Sample Obtained from Glass Plate with Different Collection Time Intervals

Minutes after shot	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	+ - +	+ - +	+ - +	+ - +
60	+ + +	+ - +	+ + +	+ - +
100	+ + +	+ + +	+ + +	+ + +
12 hours	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	+ - -	+ + -	+ - -	+ - -
60	+ + +	+ + +	+ + -	+ + -
100	+ - +	+ + -	+ + -	+ + -
1 day	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	+ - -	+ - -	+ - -	+ - -
60	+ + +	+ - +	+ + -	+ - -
100	+ - +	+ + -	+ - -	+ - -

As for the result of the cotton cloth, the DPA test gave a negative result in both guns at all distances and time intervals. For the Griess's test, both guns gave all positive results for the samples collected at 12 hours at all distances. For the samples left for 1 day for both guns at 10 cm, the sample gave 2 negative results out of 3; at 60 and 100 cm positive results were obtained under all conditions. For the samples that were tested immediately after the shooting at 10 cm, the revolver gave 2 negative results out of 3 whereas the semi-automatic pistol gave 2 positive results out of 3. At 60 and 100 cm, all results were positive. Results are shown in Table 4.

Table 4. Results of Sample Obtained from a Piece of Cotton with Different Collection Time Intervals

Minutes after shot	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	-	+ - -	-	+ + -
60	-	+ + +	-	+ + +
100	-	+ + +	-	+ + +
12 hours	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	-	+ + +	-	+ + +
60	-	+ + +	-	+ + +
100	-	+ + +	-	+ + +
1 day	Revolver		Semi-automatic Pistol	
	DPA reagent	Griess's reagent	DPA reagent	Griess's reagent
10	-	+ - -	-	+ - -
60	-	+ + +	-	+ + +
100	-	+ + +	-	+ + +

Discussion and Conclusion

According to the results, GSR was able to be collected using a piece of sponge, moistened with distilled water, on a porous surface. For a non-porous surface the material can be cut out and soaked in water for an hour. The water can then be tested for the GSR. In this investigation, it has been observed that the distance for GSR collection can affect the result. The optimal ranges for GSR collection were at 60 and 100 cm whereas at 10 cm the results may vary, but mostly a negative result is obtained. From the results, it could be observed that there is more chance of obtaining a positive result with the GSR collected from a non-porous surface. Almost all of the samples collected from a porous surface could not be detected using the DPA test. The results suggested that for a porous surface, both spot tests can detect GSR with only one bullet shot from both guns, and the optimal distance for GSR collection were at 60 and 100 cm. The positive results can be observed more clearly with more bullets shot. For the non-porous surface, it could only be tested with Griess's test. With one bullet shot, only a few positive results were obtained using both guns. The only good positive result that can be observed was at 100 cm using the revolver. As for the experiment using 3 and 5 bullets, positive results were able to be obtained at 60 and 100 cm for both guns. For the variation of collection time intervals, the results of a porous surface showed that even after leaving the sample for a day, it could still be tested positive for the GSR and the best results were from 60 and 100 cm for

both guns. As for the porous surface, if the samples were collected immediately, both spot tests could clearly detect the GSR in the samples for both guns in all distances. At 12 hours, the GSR could still be detected at 60 and 100 cm for both guns. Finally, for the sample left one day before collection, the GSR could still be easily detected at 60 and 100 cm with the revolver. On the contrary, it was harder to test for the GSR at all distances for the semi-automatic pistol. In conclusion, Griess's test appears to be superior to the DPA reagent in term of being able to test GSR on any surface, but performed equally well in other factors. The types of spot tests chosen to be used at a crime scene are more likely to rely on the situation.

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