Technical Note

A Comparison of Six Fingerprint Enhancement Techniques for the Recovery of Latent Fingerprints from Unfired Cartridge Cases

Ainsley J. Dominick [1]
Kenny Laing [2]

Abstract: This work compared the effectiveness of six different enhancement methods on six different sizes of brass cartridges. One sebaceous fingerprint was deposited onto 25 of each size of cartridge to enable a statistical evaluation of the enhancement methods for each cartridge size to be undertaken.

The enhancement methods compared were cyanoacrylate fuming (CA) followed by brilliant yellow dye staining (BY40), CA followed by gun blue (GB) followed by BY40, GB only, CA followed by palladium deposition, palladium deposition only, and powder suspension. The six sizes of cartridges used in this study were .22 cal, .32 cal, 9 mm, .38 cal, 12 gauge ribbed shotgun, and 12 gauge smooth shotgun.

Two techniques provided the best results: (1) CA followed by GB followed by BY40 and (2) CA followed by palladium deposition. These two enhancement techniques were also compared statistically and no statistical difference in their effectiveness was found, suggesting that both techniques are equally as effective at enhancing fingerprints on brass cartridge cases.

Introduction

The legal definition of a firearm according to the U.K. Firearm Act 1968 is "a lethal barrelled weapon of any description from which any shot, bullet or other missile can be discharged" [1]. Put simply, the firearm is a means of aiming and discharging a

1 Centre for Forensic Science, University of Strathclyde, Glasgow, U.K.

2 Scottish Police Services Authority Forensic Services, Mark Enhancement Laboratory, Glasgow, U.K.

Received May 14, 2010; accepted August 23, 2010

projectile. The projectile is more commonly known as the bullet, but in order for the bullet to fire, it is normally enclosed in a metallic case with a propellant and a primer. This metallic case is more commonly referred to as the cartridge case, and these are manufactured to fit the firing chamber of a firearm.

When the cartridge is loaded into the firearm, there is the potential for a fingerprint to be deposited onto the casing. However, there have been low success rates of recovering fingerprints from fired cartridge cases. This is due to factors such as friction between the cartridge case and the firearm surface, high temperature and pressure generated within the cartridge case at the moment of firing, and the cartridge case's exposure to the combustion gases and discharge residues upon firing [2]. Although fired cartridge cases can be recovered from a crime scene, it is also possible to recover unfired cartridges that have not been exposed to the factors which have been found to deteriorate the deposited fingerprint.

This study was undertaken, under laboratory conditions, to test the effectiveness of cyanoacrylate followed by BY40 against other previously published enhancement techniques of palladium deposition [3, 4] and gun blue [4–6] and also to compare it to powder suspension, of which its effectiveness on cartridge cases is unknown.

Materials and Methods

The most common sizes of casings that are recovered from crime scenes within the Strathclyde Police region are .22 cal, .32 cal, 9 mm, .38 cal, and 12 gauge shotshells. Therefore, in this study, the following brands of ammunition were used:

- .22 cal (Eley High Velocity)
- .32 cal (Remington UMC)
- 9 mm (Sellier & Bellot)
- .38 cal (Winchester Western)
- 12 gauge shotshells, ribbed (Eley Grand Prix)
- 12 gauge shotshells smooth (Winchester AA Plus)

The same brand was used for each caliber throughout the study. All cartridges were washed in ethanol and left to air-dry before fingerprint deposition occurred. Only one donor was used in this study. The donor deposited only sebaceous fingerprints (achieved by rubbing the nose and forehead before fingerprint deposition). The fingerprints deposited on the shotgun cases were placed across both the plastic and the brass surfaces to assess the ability of the fingerprint enhancement on both materials.

The six enhancement methods compared in this study were cyanoacrylate fuming followed by brillant yellow 40 dye staining (CA–BY40), cyanoacrylate fuming followed by gun blue dye staining followed by brillant yellow 40 dye staining (CA–GB–BY40), gun blue only (GB), black powder suspension, cyanoacrylate fuming followed by palladium deposition (CA-palladium), and palladium deposition only. Twenty-five new cartridges of each caliber were used for each enhancement technique.

Cyanoacrylate fuming was achieved by using 3 g of Cyanobloom (Foster + Freeman, Evesham, Worcestershire). The cartridges were placed in the fuming cabinet (Mason Vactron MVC5000, Evesham, Worcestershire) and closed. The cyanoacrylate fuming program is given in Table 1. Once completed, the cyanoacrylate residue was dyed by submerging the cartridges in BY40 (2 g in 1 L of ethanol) (Keystone, Huddersfield, West Yorkshire). They were then rinsed in cold water and left to dry overnight. The cartridges were later examined under light of 385–469 nm and viewed using a 476 nm viewing filter [7].

Cyanoacrylate Program	Time (min)	Temperature (C)	Relative Humidity (%RH)
Initializing	1	24	66
Humidity	15	25	70
Glue	20	120	80
Initializing	1	110	80
Purge	40	reducing to 29	reducing to room humidity

Table 1

Cyanoacrylate fuming cycle program.

Gun blue and palladium deposition react with the substrate on which the fingerprint has been deposited rather than with the actual fingerprint deposit. The gun bluing process is essentially an artificial rusting process using a specially prepared oxidizing solution containing selenious acid (H_2SeO_3) and a cupric salt in an acid solution. When selenious acid and cupric ions are reduced (as they can oxidize certain metals), a black copper-selenide coating is formed on the metal surface, leaving the fingerprint intact [2, 6]. Palladium deposition is a displacement process that involves the oxidation of the metal, resulting in the deposition of palladium [2].

The gun blue solution was prepared by adding 2.3 mL of Super Blue Liquid Gun Blue (Birchwood Casey, Eden Prairie, Jacksonville, Minnesota) to 97.7 mL distilled water [8]. For the gun bluing portions of the CA–GB–BY40 and GB processing techniques, the cartridges were submerged in gun blue solution until sufficient development occurred (only the brass part of the shotgun cartridges was submerged). The bluing process was then halted by submerging the cartridges in distilled water before air-drying overnight. If BY40 dyeing was required, this was undertaken on the following day.

For the CA-palladium and palladium only deposition techniques, the solution was prepared by adding palladium chloride (0.88 g) to 50 mL distilled water containing sodium chloride (2.929 g) and stirring constantly until the palladium dichloride dissolved. The cartridges were submerged in the palladium solution for 40 seconds before rinsing in distilled water (again, only the brass part of the shotgun cartridges was submerged).

The powder suspension used in this study was a 1:1 mixture of dark adhesive-side powder and EZFLO solution (both Sirchie, Youngsville, NC) and it was applied using a squirrel-hair brush. The powder suspension was rinsed off using cool tap water from a hand-held sprayer after eight seconds.

Results and Discussion

As previously stated, 25 of each type of cartridge were exposed to each enhancement technique. Therefore, if all fingerprints were enhanced by a particular enhancement technique, a total of 25 identifiable fingerprints would be recovered. Table 2 gives the number of these fingerprints recovered for each enhancement method.

A Kolmogorov-Smirnov test was undertaken to assess the normality of the data distribution. Figure 1 is the normality plot generated using Minitab.

Cartridge	Number of Fingerprints Recovered for Fach Enhancement Technique					
	CA-BY40	CA-GB-BY40	GB Only	Powder Suspension	CA-Palladium	Palladium Only
.22	4	4	1	0	6	0
.32	13	20	9	0	23	14
9mm	14	21	2	4	20	16
.38	13	24	13	0	25	19
Ribbed shotgun	24	24	8	7	25	13
Smooth shotgun	25	25	16	10	25	13

Table 2

Number of fingerprints enhanced using various enhancement techniques on various cartridges.

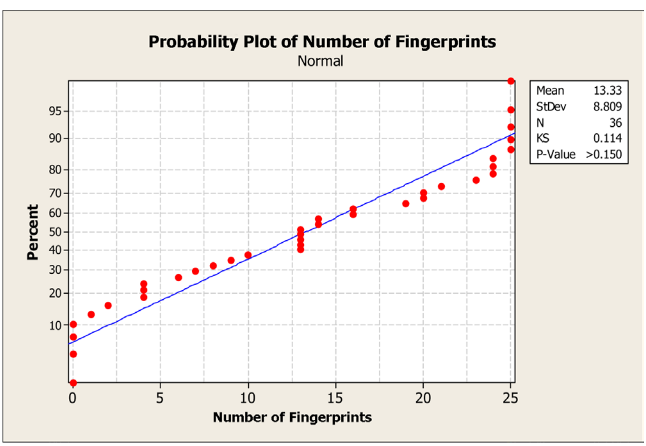

Figure 1

Normality plot for number of fingerprints enhanced on cartridge cases.

The Kolmogorov-Smirnov normality test produces a P-value; in this case, the P-value is >0.15. This value is compared to the test statistic, which is an α value of 0.05. If the P-value is greater than the α value, then the data is normally distributed. If the P-value is less than 0.05, then the data is not normally distributed [9]. From these results, it can be seen that the data is normally distributed. Therefore, further statistical tests, such as analysis of variance, can be performed because of the normality of the data.

A balanced analysis of variance (ANOVA) test was conducted that investigated the factors which were varied during the experiment (type of cartridge and enhancement technique) in order to determine their effect on the response variable (number of fingerprints). The ANOVA calculation is used to determine which of the effects in the model are statistically significant by generating the P-value. This P-value is compared to the α value of 0.05, with $P < 0.05$ indicating the variable has a significant effect on the response or $P > 0.05$ indicating no significant effect on the response [9]. The ANOVA test for each variable (type of cartridge and enhancement technique) both produced P-values of 0.000. Therefore, both variables have a significant effect on the number of fingerprints that were enhanced.

A main effects plot can also be generated on Minitab that calculates the mean number of fingerprints recovered for each cartridge size and enhancement technique. This plot is given in Figure 2.

The main effects plot shows that for all cartridge sizes, CA–palladium is the most effective technique, closely followed by CA–GB–BY40. Powder suspension produced the poorest results. Upon examining the mean results in terms of cartridge size, it is clear that as the cartridge size increases, the number of fingerprints that can be recovered increases. The poor results seen by GB only compared to its inclusion in the CA has also been witnessed by Dr. George Saunders while working with the U.S. Secret Service [10, 11].

An interaction plot was also generated using Minitab that examined the interaction between the two variables. This is given in Figure 3.

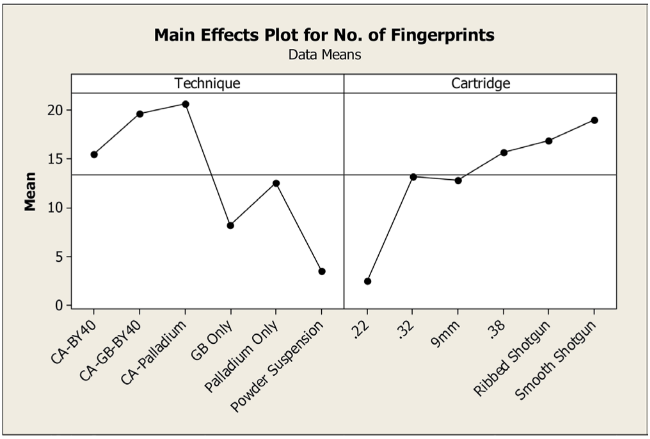

Figure 2

Main effects plot for number of fingerprints.

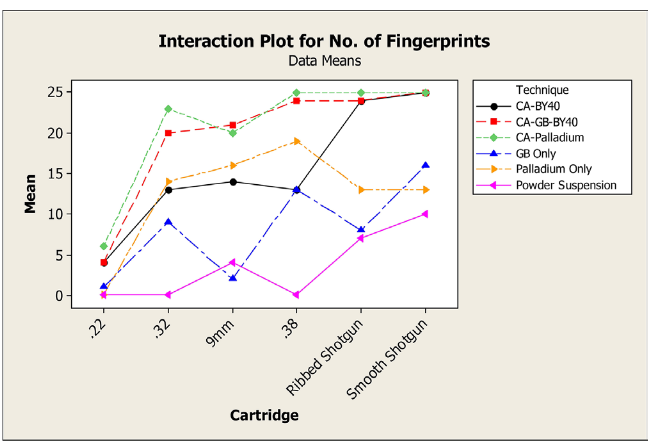

Figure 3

Interaction plot for number of fingerprints

(y-axis = mean number of fingerprints).

The interaction plot shows that for all cartridge sizes, the CA–palladium consistently produced more fingerprints (except for 9 mm cartridges) than any other technique. Only one more fingerprint was enhanced on 9 mm cartridges by CA–GB–BY40 than by CA–palladium. Therefore, CA–palladium can be considered the most effective enhancement technique for a range of cartridge sizes.

Because both CA–palladium and CA–GB–BY40 produced very similar results, the reproducibility of the two techniques was assessed by repeating the tests a second time. The results are given in Table 3.

Cartridge	Number of Fingerprints Recovered			
	CA-Palladium		CA-GB-BY40	
	Initial Test	Repeated Test	Initial Test	Repeated Test
.22	6	4	4	3
.32	23	24	20	21
9 mm	20	21	21	22
.38	25	22	24	21
Ribbed shotgun	25	25	24	23
Smooth shotgun	25	25	25	23

Table 3

Results of the reproducibility study.

A Kolmogorov-Smirnov test was undertaken to assess the normality of the data and this gave a P-value of <0.010 for each enhancement technique. Therefore, the data was not normally distributed for both techniques. To test for a statistical difference in the two enhancement sets, it was not possible to undertake ANOVA tests because the data was not normally distributed. Therefore, Kruskal-Wallis tests were undertaken that assess the medians in the data sets, also by generating P-values. The P-values are also tested against an α value of 0.05, and this will indicate whether there is a statistical difference between each set (sets 1 and 2) for each enhancement technique [9]. The Kruskal-Wallis P-value generated was 0.103 for CA–palladium, which indicated that there was no significant difference in the number of fingerprints recovered using this technique. The Kruskal-Wallis P-value was 0.125 for CA–GB–BY40, which indicated that there was no significant difference in the number of fingerprints recovered using this technique also. This shows that both techniques are reproducible.

An interaction plot was also generated on Minitab for this reproducibility data to assess whether CA–palladium is most effective across all cartridge sizes (except for 9 mm) as shown in Figure 3. This interaction plot is given in Figure 4.

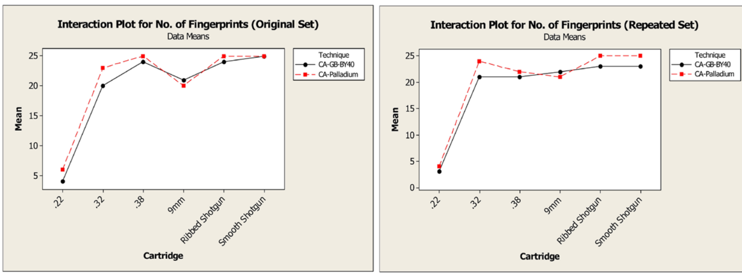

Figure 4

Interaction plot for reproducibility tests

(y-axis = mean number of potentially identifiable fingerprints).

This interaction plot shows that CA–GB–BY40 was still superior on the 9 mm cartridge cases. CA–palladium was still more effective on the other five calibers. However, the number of fingerprints recovered using each technique was very close for each size of cartridge.

A Kruskal-Wallis test was also performed to assess whether there was a statistical difference in the results for each enhancement technique. This produced a P-value of 0.285, which, when compared to the α value of 0.05, showed that there was no difference in the results obtained by each technique. Therefore, statistically, there was no difference in the results obtained by either CA–GB–BY40 and CA–palladium.

Palladium chloride is more expensive than the gun blue solution, therefore, the CA–palladium is the more expensive technique of the two. However, an examination of the cartridges can be undertaken the day after treatment, whereas the CA–GB–BY40 takes two days before examination can be undertaken (to allow the cartridges to dry overnight from the gun blue submersion on day one and then to dry overnight from the BY40 submersion on day two). Therefore, each enhancement laboratory must weigh these two options when deciding which enhancement method to use.

Conclusion

In conclusion, six enhancement techniques were tested to determine the most effective enhancement method for unfired cartridge cases. Two techniques were found to be superior to the others examined: CA–palladium and CA–GB–BY40. Statistically, these enhancement methods are equally as good as each other although graphically, CA–palladium produced marginally better results on five of the six cartridge sizes tested. Therefore, the introduction of a specific metal treatment into an already common nonporous fingerprint enhancement technique increases the yield of potentially identifiable fingerprints recovered from unfired cartridge cases.

For further information, please contact:

Ainsley J. Dominick
Centre for Forensic Science
University of Strathclyde
Royal College 204 George Street
Glasgow G1 1XW
United Kingdom
ainsley.dominick@strath.ac.uk

References

1. *Firearms Act 1968*; United Kingdom Public General Acts, Chapter 27, Part IV, Section 57 (1).
2. Champod, C.; Lennard, C.; Margot, P.; Stoilovic, M. *Fingerprints and Other Ridge Impressions*; CRC Press: Boca Raton, FL, 2004; pp 164–166.
3. Migron, Y.; Mandler, D. Development of Latent Fingerprints on Unfired Cartridges by Palladium Deposition: A Surface Study. *J. For. Sci*. **1997**, *42* (6), 986–992.
4. Migron, Y.; Hocherman, G.; Springer, E.; Almog, J.; Mandler, D. Visualization of Sebaceous Fingerprints on Fired Cartridge Cases: A Laboratory Study. *J. For. Sci*. **1997**, *43* (3), 543–548.
5. Bentsen, R. K.; Brown, J. K.; Dinsmore, A.; Harbey, K. K.; Kee, T. G. Post Firing Visualisation of Fingerprint on Spent Cartridge Cases. *Sci. Justice*, **1996**, *36* (1), 3–8.
6. Cantu, A. A.; Leben, D. A.; Ramotowski, R.; Kopera, J.; Simms, J. R. Use of Acidified Hydrogen Peroxide to Remove Excess Gun Blue from Gun Blue-Treated Cartridge Cases and to Develop Latent Prints on Untreated Cartridge Cases. *J. For. Sci*. **1998**, *43* (2), 294–298.

7. Bowman V., Ed. *Manual of Fingerprint Development Techniques*. 2nd ed. 2nd rev.; Home Office, Police Scientific Development Branch: Sandridge, U.K., 2004.
8. Sears, V. Higher Scientific Officer, Home Office Scientific Development Branch, Sandrich, UK. Personal Communication.
9. Minitab Inc, Minitab StatGuide, in Minitab v.15 software.
10. Saunders, G. C.; Cantu, A. A. Evaluation of Several Techniques for Developing Latent Fingerprints on Unfired and Fired Cartridge Cases. In *Proceedings of the International Symposium on Fingerprint Detection and Identification*, Ne'urim, Israel, June 26–30, 1995; Almog, J., Springer, E., Yisrael, M., Eds., Israel National Police: Jerusalem, Israel, 1996, pp 155–160.
11. Ramotowski, R.; Cantu, A. A. Recent Advances in Latent Print Visualization Research. *Chesapeake Bay Exam*. **1998**, *36* (2), 18–21.