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Morrissey, J, Larrosa, J and Birkett, JW (2017) A preliminary evaluation of the use of gun bluing to enhance friction ridge detail on cartridge casings. Journal of Forensic Identification, 67 (3).

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Technical Note

A Preliminary Evaluation of the Use of Gun Bluing to Enhance Friction Ridge Detail on Cartridge Casings

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Abstract: Friction ridge detail was enhanced on fired and unfired 9 mm brass Luger ammunition casings using three techniques, two involving gun blue reagent at a concentration of 50% v/v. Fingermarks were deposited on 90 ammunition casings, and half were discharged using a Glock 19 semiautomatic pistol. Mark development was achieved using either superglue fuming followed by basic yellow 40 fluorescent dye staining (SG → BY40), superglue fuming followed by gun blue (SG → GB), or gun blue (GB) as a single process. All three processes developed ridge detail on both fired and unfired casings. The results of this preliminary work show that the use of gun blue as a single enhancement technique was able to enhance ridge detail of the highest quality and clarity, particularly on fired casings, making it the most effective process.

Introduction

Friction ridge detail can be latent, patent, or plastic, and common contaminants are blood, dirt, dust, and grease. Sweat and oil, produced from eccrine and sebaceous glands, are secreted from the pores and distributed across the skin. When a person touches a surface, these contaminents may be deposited in the form of friction ridge detail. These marks cannot always

Received November 9, 2016; accepted February 21, 2016

be seen with the naked eye, or even with high-intensity light sources, and therefore require the use of chemical enhancement processes to make the marks visible.

In 2015, recorded firearms offenses in the United Kingdom rose by 2% to just under 8000 incidents [1]. This figure is low compared to the frequency of other crime types; however, firearms offenses are often high profile and often heavily reported by the media. As a result, there is an increased demand for forensic processes to aid these investigations.

The success rate for enhancing friction ridge detail on ammunition casings is particularly low. This could be due to a number of factors: the metal surface, the environment of storage, or the conditions endured during the firing process. The casing is subjected to friction during loading and firing, as well as high temperatures, pressure, and combustion gases, potentially damaging any friction ridge detail [2].

The Centre for Applied Science and Technology (CAST) *Fingermark Visualisation Manual* contains guidance on which chemical processes are the most effective on a range of surfaces, as determined by extensive research [3]. Local police force policies also provide additional guidance that is based on the experience of laboratory officers and the resources available to that force. This experience is often required, because some surfaces will not fit into a category with a recommended most effective treatment.

Gun blue is a chemical that is typically used to maintain and improve the metal finish of firearms, protecting against rusting and scratches. However, it is also a process that is capable of developing friction ridge detail on surfaces such as brass, a common metal that is used to make ammunition casings. Gun blue contains three active ingredients: an acid, cupric salt, and selenious acid. These ingredients form an oxidizing agent that is able to react with metals and alloys to form a copper selenide coating. The reaction is essentially an induced rusting, as per the chemical reaction below [4].

$$H_2SeO_3 + 4H+ + 4e- \rightarrow Se + 3H_2O \text{ (general reaction)}$$

The gun blue solution reacts with the metal surface only, and this cannot take place if the surface is contaminated with a greasy or oily deposit or other contaminant, such as a latent print, which is what allows the print to be visualized as a blue-black deposit.

Cantu et al. stated that diluted gun blue can enhance ridge detail on fired casings; however, results using superglue fuming were poor [2]. Bentsen et al. found that both superglue fuming and gun blue treatments were highly sensitive and able to develop fingermarks of varying quality on a range of ammunition types [5]. Girelli et al. stated that superglue fuming followed by treatment with gun blue and then BY40 was the most effective process [6]. Work carried out by Dominick et al. agreed with this conclusion, however, they noted that gun blue used alone yielded poor results [7]. The studies mentioned indicate the extent of uncertainty relating to the optimum process for chemically enhancing friction ridge detail on brass ammunition casings.

The aim of this work was to identify whether superglue fuming and basic yellow 40 fluorescent dye (SG → BY40), superglue fuming followed by gun blue (SG → GB), or gun blue (GB) alone was the most effective process for developing ridge detail on fired and unfired casings.

Materials and Methods

Deposition of Fingermarks

Brass ammunition casings (9 mm Luger) supplied by Merseyside Police were used throughout the study. Casings were cleaned by gently rubbing the surface with white lint-free tissue wetted with 100% ethanol. It is acknowledged that cleaning in this manner may remove any manufacturing contaminants that might be present externally, which could have an impact on print development. However, it was considered necessary in order to identify a baseline reaction between the surface of the casing, the chemical reagents, and the resulting fingermark development.

One donor was used throughout this study to ensure that fingermarks of comparable quality and deposition pressure were left on each casing. The donor washed and dried her hands and then clenched her hands for one minute and deposited a single fingermark from either the fore or middle finger of either hand on the casing surface. All fingermarks were deposited pointing toward the head of the casing. All samples (fired and unfired) were processed within 12 hours.

Gun Blue Protocol

A dilution of 50% Birchwood Casey Perma Blue solution and 50% distilled water was used. Each casing was carefully held by the head using plastic tweezers and lowered into the solution. A timer was started upon contact with the solution. The casing was carefully monitored and when ridge detail of sufficient quality was developed, the casing was removed from the solution and placed into a beaker of distilled water to halt the reaction. These timings were recorded to evaluate the optimum time for development. The protocols used for superglue and BY40 followed CAST guidelines [3].

Ridge Detail Evaluation

The ridge detail that developed was examined and given a grade as detailed in Table 1.

All grading was done by examining the mark on the casings using a white light, a blue crime-lite (Crime Lite 2, 420–470 nm, Foster and Freeman, Evesham, U.K.), and a fingerprint glass. The photographs of all impressions were also used for this purpose. Independent grading was also conducted by a second examiner, and all gradings were agreed upon.

Grade	Criteria
0	No ridge detail developed.
1	No clear pattern or ridge flow, with few or no characteristics disclosed. Cannot be used for identification purposes.
2	Pattern or ridge flow is disclosed, however characteristics are not clear throughout the whole impression. May possibly be used for identification purposes.
3	Pattern and/or ridge flow is disclosed with clear characteristics throughout. Identifiable ridge detail.

Table 1

Outline grading scheme used for assessment of developed marks.

Cartridge Case Development

A fingermark was deposited as previously discussed on 15 cartridge casings. Five of the casings were then enhanced using superglue fuming followed by BY40 fluorescent dye and allowed to air-dry overnight.

Five of the casings were enhanced using gun blue at a 50% v/v concentration and allowed to air-dry overnight.

Five of the casings were enhanced using superglue fuming and then were further enhanced with gun blue. These were allowed to air-dry overnight.

This process was carried out 3 times, on 3 separate days, with 15 unfired casings in total being processed using each method.

The above process was repeated using casings fired by a Glock 19 semi-automatic pistol. Fingermarks were left on the casings prior to firing, and the rounds were loaded into the weapon by an officer wearing gloves to prevent any additional deposition of latent prints. The weapon was immediately discharged and the casings (45 in total) were processed using each of the three different methods described[1].

Results and Discussion

A concentration of 50% v/v gun blue was chosen for use in this study because testing by practitioners has shown this to be the most effective concentration [7].

Dominick et al. used "Super Blue Liquid Gun Blue" (Birchwood Casey) at a concentration of just above 2%, and they were able to develop sebaceous marks across a variety of unfired ammunition types; however, the quality of these marks is not known [8].

Bentsen et al. used selenious acid at a concentration of 0.4%. However, it was noted that few marks of identifiable quality were enhanced [5]. James et al. used lower concentrations of a patination fluid, and results showed that concentrations of less than 20% produced poor results on eccrine sweat deposits [9]. The work reported here, using a concentration of 50%, consistently developed marks that were identifiable and of a higher quality.

Brass casings were used in this study because research had identified that the method was most effective on this surface [3]. Further research on other types of casings is ongoing, and it is acknowledged that the chemical composition of the cartridge casings may affect the results achieved.

Development Time

Development times for each casing varied between 20 and 42 seconds across all samples, with a mean of 32 seconds for development. Some casings were readily enhanced and ridge detail was observed quickly, whereas others developed much more gradually, with faint ridge detail forming and then slowly darkening. No further development was noted after 42 seconds.

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[1] This preliminary study will inform a much larger study now being conducted.

Cantu et al. suggest close and careful monitoring of the casing at all times during treatment, rather than the use of a specific number of seconds [2]. The work carried out in this study would support that as part of a standard procedure.

Unfired Casings

Ridge detail enhancement was observed on unfired casings using all three techniques as shown in Figure 1.

Girelli et al. and Dominick et al. both reported that SG → GB was the most effective treatment for brass casings, although Dominick also found that superglue and palladium gave equally good results [6, 8]. It is important to note that Girelli used natural fingermarks, whereas Dominick used sebaceous prints [6, 8].

Our results indicate that, although SG → GB was effective, it was much less so than SG → BY40 and GB alone. A possible explanation for this could be that the superglue fuming process was too heavy. Migron et al. state that a light superglue fuming should be carried out first, perhaps only a 5-minute cycle [10]. Cantu et al. commented that any mark present may not be visible after this process has been carried out [2]. In this study, a 20-minute glue cycle was used, resulting in a clearly visible deposit. When the glued casings were treated with GB, there was no visible change in the appearance of the marks or the casing as a whole.

Because the GB process works around the oily or fatty deposits of the mark, if the glue coated the entire surface of the casing, including the oily deposits and brass surface, this would hinder the GB enhancement process, explaining why there seemed to be no effect after treatment with SG.

One of the most appealing qualities of the SG → GB process is that the SG stage can be carried out first, which is a trusted, reliable, validated process that rarely overdevelops marks. GB alone has the potential to overdevelop and destroy a mark if the process is not carefully observed.

Fired Casings

Figure 2 shows that the firing process did not have a large effect on marks enhanced using GB because this process interacts with the brass surface and oily deposits. However, a high temperature during firing could partially evaporate the water constituent of the mark, leaving less or little to be enhanced. This is likely to have affected the marks deposited on casings to be fired, and explains the lower grade total. Sampson and Bentsen et al., who found ridge detail development using superglue fuming to be variable, also reached this conclusion [11, 5].

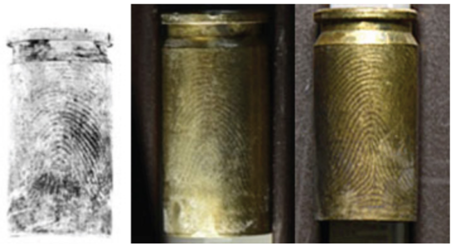

Figure 1

(Left to Right) Unfired casings enhanced with SG → BY40, SG → GB, and GB.

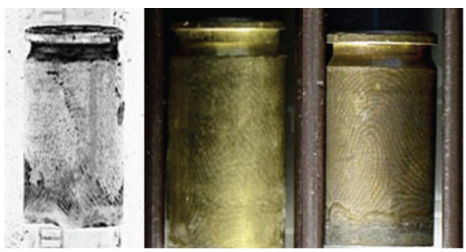

Figure 2

(Left to Right) Fired casings enhanced with SG → BY40, SG → GB, and GB.

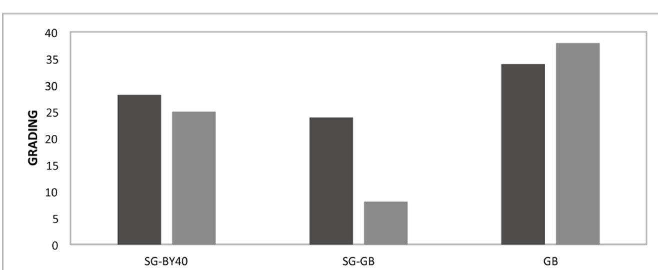

Figure 3

Cumulative ridge detail grading for each technique.

Ridge Detail Evaluation

Each casing was examined after processing, and the quality and clarity of ridge detail were evaluated according to the scale in Table 1. The results presented in Table 2 and Figure 3 clearly indicate that gun blue alone is the most effective process when used on both fired and unfired casings.

In order to provide an assessment of the evaluation of each method, Figure 3 shows a cumulative grading for each method. This clearly illustrates that gun blue alone is a more effective process for unfired and particularly fired casings.

Enhancement Method	Number of Grade 3	Number of Grade 2	Number of Grade 1	Number of Grade 0
GB–Unfired	6	7	2	0
GB–Fired	9	5	1	0
SG → GB–Unfired	3	3	9	0
SG → GB–Fired	0	0	8	7
SG → BY40–Unfired	5	5	5	0
SG → BY40–Fired	3	5	6	1

Table 2

The number of each grade assigned per enhancement method.

Conclusion

SG → BY40 is the current most effective validated process used by police laboratories nationwide, and the results on unfired casings supported that this process is effective. However, this work has shown that gun blue alone developed the best overall quality ridge detail on both fired and unfired cartridge casings, utilizing a small amount of the chemical with a treatment time lasting only seconds. SG → GB produced poor results overall when enhancing both unfired and fired casings, although this may be improved with the use of a lighter glue cycle.

The authors are continuing to develop this initial work, focusing on the enhancement of friction ridge detail under a range of conditions and surfaces with a larger sample size. Overall, this research has found that gun blue can quickly and successfully enhance ridge detail of an identifiable quality, using a reliable and straightforward protocol.

Acknowledgment

The authors would like to thank Merseyside Police for providing access to ballistic materials used for this study.

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