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TECHNICAL NOTE

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Determining an Optimal Sequence for Chemical Development of Latent Prints on Cartridge Casings and Shotgun Shells*,†

ABSTRACT: In developing latent prints on cartridge casings and shotgun shells, multiple chemical processes should be used in order to obtain the best results. In Phase I, this study established an optimal chemical sequence for both Brass and Nickel cartridge casings based on six sequences involving four chemicals: Cyanoacrylate, Black Powder, Rhodamine 6G and Acidified Hydrogen Peroxide. Phase II was a validation study of Phase I involving a random sample of both Brass and Nickel cartridge casings, which were processed according to the determined optimal sequences. In addition, ribbed shotgun shells were processed under Phase I results and determined to be dependent upon the utilization of a CrimeScope at 515 nm. Consideration should be given to the type of cartridge case being examined. Although limitations exist, some chemical sequences undeniably work better than others. All photographs were manipulated with Adobe® Photoshop®. All results were verified by a senior latent print examiner.

KEYWORDS: forensic science, latent prints, cartridge casings, shotgun shells, gun blueing, acidified hydrogen peroxide, CyanoVac, Adobe® Photoshop®, Nikon D2X, CrimeScope

Latent prints remain hidden until visualized with chemical enhancements. There is a common frustration shared among analysts in attempting to obtain prints of value from items such as cartridge casings. The purpose of this study was to investigate different sequences of chemical processing in order to find an optimal method for developing latent prints on varying cartridge casings and shotgun shells. More specifically, the main focus was to view the effects of Acidified Hydrogen Peroxide. Other studies have involved Gun Blueing techniques, but this solution was not considered because in comparison, Acidified Hydrogen Peroxide provides a lower chance of overdevelopment in friction ridge detail (1). Also, the Acidified Hydrogen Peroxide formula has been found to "clean" (oxidize or etch) metal cartridge cases in areas where there was no sebaceous latent print material or other substances that resist oxidation (2). In determining an optimal sequence, Nickel casings were expected to produce more ridge detail than Brass casings after Cyanoacrylate fuming and post-Acidified Hydrogen Peroxide. Also, there was an expectation of little or no development on the shotgun shells.

Phase I included six sequences involving Brass and Nickel cartridge casings (Table 1). All six sequences considered Cyanoacrylate as a first step due to its typically nondestructive nature. The Super glue fumes adhere to latent fingerprints, which results in robust, off-white friction ridge impressions that provide a foundation for further chemical processing (3). For example, according to a Technical Note of Rhodamine 6G, it is not only necessary to Super glue an item before using Rhodamine 6G, but it is also recommended to underfume rather than overfume due to a possibility of producing bright glowing globs and thereby losing ridge detail (4).

Phase II included a random sample of Brass and Nickel cartridge casings, which were processed according to the optimal sequences found, with respect to casing type, under Phase I. Similarly, shotgun shells were divided between the two Brass and Nickel groups and were processed under Phase I results.

Methods—Phase I

Sample

Fired cartridge cases and shotgun shells were obtained from the Firearms section. The items were submerged in a tray of methanol and wiped with a towel in order to remove prior latent prints. Six, large weigh boats were numbered 1–6 with a black Sharpie and each contained the following 10 casings: 2 Brass 0.45, 2 Nickel 0.45, 2 Brass 0.40, 2 Nickel 9 mm and 2 Brass Rifle (Table 2). An additional large weigh boat 7 contained 10 Remmington "ShurShot" plastic, ribbed 12 gauge $2^{3/4}$ inch shotgun shells. Each item within the weigh boat was labeled on the head stamps with subunits A–J with "i" in lower case as to not confuse it with "H."

Chemical Processing

Prints were randomly placed on all items while being vigorously handled with unwashed hands, except for A's in order to create controls. The donors included the authors of this study and two Latent analysts. All items were placed in a CyanoVac chamber "VAC200" along with a test print for 1 h at −15 in Hg vacuumed pressure. "Quarter" size amounts of Cyanoacrylate were dispersed in two aluminum boats at each end of the vacuum. One hour later, the items were removed from the CyanoVac chamber and left overnight for 24 h.

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TABLE 1—*List of six chemical sequences used.*

1. Cyanoacrylate—Powder—Rhodamine 6G—Acidified Hydrogen Peroxide
2. Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G
3. Cyanoacrylate—Rhodamine 6G—Powder—Acidified Hydrogen Peroxide
4. Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder
5. Cyanoacrylate—Acidified Hydrogen Peroxide—Powder—Rhodamine 6G
6. Cyanoacrylate—Acidified Hydrogen Peroxide—Rhodamine 6G—Powder

TABLE 2—*Set-up: six large weigh boats containing cartridge casings of subunits A–J.*

A: Nickel 0.45
B: Nickel 0.45
C: Brass 0.40
D: Brass 0.40
E: Brass 0.45
F: Brass 0.45
G: Nickel 9 mm
H: Nickel 9 mm
i: Brass Rifle
J: Brass Rifle

Photographs were taken, which included overall photographs of weigh boats 1–7 and individual photographs of all weigh boats with their subunits A–J, which was documented in a spreadsheet. The camera used was a Nikon D2X (Norman Camera, Kalamazoo, MI) with a 60 mm F2.8 lens and 105 mm Macro lens, which was used on a Polaroid MP 4+ Instant Camera System. Oblique lighting with Model 760-SG and CrimeScope CS-16 (SPEX Forensics/Horiba Jobin Yvon, Edison, NJ) was selectively used and noted in the photograph log. All photographs were taken to scale.

Individually, the casings in weigh boats 1 and 2 were powdered with Lightning Black Powder. Once completed, overall photographs were taken of both weigh boats and documented as "Boat 1—Powder" and "Boat 2—Powder." Next, a fresh working solution of Rhodamine 6G was prepared. Due to the extreme concentration of Rhodamine 6G, a paperclip was dipped into the dye Powder to a depth of *c.* 1 cm. The dye Powder obtained was placed in 1200 mL of methanol, which was spun with a spin vane and stirred for 5 min. The solution was verified to fluoresce with a MCS-400 CrimeScope at 515 nm. The working solution was poured into a plastic squirt bottle. A portion of the solution was poured into an additional large weigh boat. The casings in weigh boats 1, 3, and 4 were treated with the Rhodamine solution. Tweezers were used to grip the items as they were dipped in the solution. Items were placed on a paper towel to let air dry. Overall photographs were taken of weigh boats 1, 3, and 4 with appropriate logged information. At this time, weigh boats 1 and 2 were given new weigh boats in order to reduce powder contamination. Acidified Hydrogen Peroxide was prepared. The 5% solution was calculated as:

$$25 \text{ mL Glacial Acetic Acid} + 475 \text{ mL Distilled Water}$$

According to published methods, 14.1 mL of 5% vinegar was suggested along with 20 mL of 3% Hydrogen Peroxide to obtain the Acidified Hydrogen Peroxide (1). This calculated solution was made six times larger in order to process weigh boats 1, 2, 4, 5, and 6. Hence, *c.* 204.6 mL was the resulting mixture. Once the solution was prepared, weigh boats 1, 2, 4, 5, and 6 were processed with the solution. The cartridge casings were immersed in the reagent by being gently stirred and rolled in a 400 mL beaker for 30 sec. After, each item was immersed in a water bath for 2 min and allowed to air dry.

Observations were documented through visual examination and photography. Overall photographs were taken of weigh boats 1, 2, 4, 5, and 6. All photographs were edited with Adobe® Photoshop® by adjusting the brightness and contrast. A Photoshop Log was obtained with exact details as to what was manipulated. Additional photographs of set-up and reagents were also taken.

Black Powder was brushed on the casings of weigh boats 3, 4, and 5. Weigh boats 4 and 5 were given new weigh boats in order to reduce powder contamination during further processing. Overall photographs of weigh boats 3, 4, and 5 were taken. Visual observations were documented. The casings in weigh boats 2, 5, and 6 were processed with Rhodamine 6G in the same manner as before with weigh boats 1, 3, and 4. Overall photographs of weigh boats 2, 5, and 6 were taken and logged. Again, Acidified Hydrogen Peroxide was used in the same manner, but this time immersing the contents of weigh boat 3. The casings of weigh boat 6 were now exposed to Black Powder. Overall photographs of weigh boats 3 and 6 were taken. All weigh boats underwent their own sequence of chemical processing. At this end stage, observations were made and subunits A–J of weigh boats 1–6 were photographed. Additionally, a CrimeScope CS-16 at 515 nm (Orange) was utilized to visualize Rhodamine 6G's effect of fluorescence. All items with fluorescing ridge detail were photographed.

Results—Phase I

Weigh Boat 1

Cyanoacrylate—Powder—Rhodamine 6G—Acidified Hydrogen Peroxide—Without the CrimeScope, the number of visible ridge lines was not consistent for both Nickel and Brass casings. The range included 0–16 ridge lines with the majority at 0–6 lines.

With the CrimeScope, Item C, a Brass 0.40, became potentially identifiable when increasing from 16 visible ridge lines to 30 lines and developing a core. Item D, another Brass 0.40, had two visible ridge lines which developed into 16 lines along the outer edges, outlining the print. Item i, a Rifle casing, went from six visible ridge lines to 20, but again only along the outer edges.

Weigh Boat 2

Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G—Without the CrimeScope, the range of visible ridge lines was 0–20, with the majority at 13–20 lines. One casing was potentially identifiable, which was Item G, a 9 mm Nickel casing, with 19 visible ridge lines, including a core.

With the CrimeScope, Item G, a 9 mm Nickel casing, became potentially identifiable with an increase of seven visible ridge lines, resulting in two more minutiae. Item C, a Brass 0.40, was noted as having three short ridge lines before the CrimeScope. After using the CrimeScope, four separate prints were noticeable with 5, 13, 15, and 18 ridge lines. Item D, another Brass 0.40, went from 20 to 27 visible ridge lines (Fig. 1). Another print was also found on Item D, which had 23 visible ridge lines. Both prints were potentially identifiable.

Weigh Boat 3

Cyanoacrylate—Rhodamine 6G—Powder—Acidified Hydrogen Peroxide—Without the CrimeScope, the range of visible ridge lines was 0–8 with the higher end referring to Nickel casings. A "faint appearance" was a description given to all Brass casings. An outlier appeared with 30 visible ridge lines, which was Item B, a Nickel 0.45

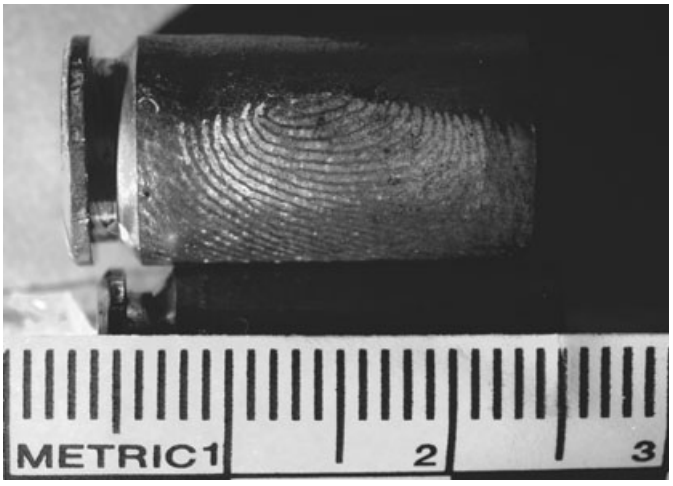

FIG. 1—*Results: subunit D (Brass 0.40) of weigh boat 2 with chemical sequence: Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G.*

casing that was potentially identifiable with the entire surface covered including a visible core.

With the CrimeScope, Item B did not have ridge lines that fluoresced. Item E, a Brass 0.45, had eight short, and very faint ridge lines that developed into 15, faint ridge lines. In addition, the outline of the print was distinguished. Similarly, Item F, another Brass 0.45, had no visible ridge lines, but the CrimeScope assisted in visualizing the outline of the print with short ridges.

Weigh Boat 4

Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder—Without the CrimeScope, the majority of the casings had a range of 8–24 visible ridge lines. Minutiae were found in five of the 10 items, but only Item B, a Nickel 0.45, had potential to be of value.

With the CrimeScope, three casings were potentially identifiable, which included Item B, a Nickel 0.45, Item C, a Brass 0.40, and Item F, a Brass 0.45 casing. Items B, C, F, and J all contained minutiae. More specifically, the CrimeScope did not seem to enhance the results of Item B. Item C went from eight to both 16 and 23 visible ridge lines with at least 10 visible minutiae. Item F went from 20 to 25 visible ridge lines with an increase of at least five visible minutiae.

Weigh Boat 5

Cyanoacrylate—Acidified Hydrogen Peroxide—Powder—Rhodamine 6G—Without the CrimeScope, the range of visible ridge lines was 0–3 with Item F, a Brass 0.45, being an outlier with seven lines. A "smudged appearance" was a description given to all casings, which tended to cover entire surfaces.

With the CrimeScope, only Item F seemed to improve under the CrimeScope. There was an increase from seven to 15 visible lines. However, none of the items in weigh boat 5 contained any visible minutiae.

Weigh Boat 6

Cyanoacrylate—Acidified Hydrogen Peroxide—Rhodamine 6G—Powder—Without the CrimeScope, the range of visible ridge lines was 0–10 with two outliers of 19 and 28 lines, which referred to Items B and E, a Nickel 0.45 and a Brass 0.45 casing. Common descriptions included "faint or smudged" appearances for all types of casings with only Item E, a Brass 0.45, with any noticeable minutiae.

With the CrimeScope, Item C, a Brass 0.40, was noted as "faint" but enhanced to 18 visible lines along the entire surface. Item D, another Brass 0.40, gained 15 noticeable lines with at least four more visible minutiae. Item E, a Nickel 0.45, became potentially identifiable while increasing from two to at least six visible minutiae. Item F, a Brass 0.45, went from being "smudged" with two visible ridge lines to becoming two separate prints with 18 and 36 visible lines, the latter of which potentially being identifiable.

Conclusions—Phase I

Results were verified by a senior latent print examiner. Two Brass casings were found potentially identifiable in both weigh boats 2 and 4. However, weigh boat 2 contained Item D, a Brass 0.40, which far exceeded all Brass items with at least 17 minutiae. Therefore, weigh boat 2 with the chemical sequence, Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G, was determined to be the optimal sequence for Brass casings. One Nickel casing was found potentially identifiable in weigh boats 2, 4, and 6. However, when referring to the visible ridge lines, weigh boat 2 had descriptions of "short and broken," weigh boat 4 had descriptions of "covered entirely," and weigh boat 6 had descriptions of "smudged." Therefore, weigh boat 4 with the chemical sequence, Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder, was determined to be the optimal sequence for Nickel casings.

Methods—Phase II

Sample

Based on Phase I results, weigh boat 7 was divided in half in a way such that five shotgun shells would be processed as weigh boat 2 was, and the remaining five would be processed as weigh boat 4 with item A acting as a control like before, which was denoted as 7:(A–E) and 7:(F–J). Twenty more cartridge casings were obtained from the Firearms section. The recovered cartridge casings were test rounds that were once loaded, fired, gathered, and discarded by the Firearms Section analysts. Given that most analysts do not wear gloves when completing this task, it was not necessary to clean the casings with methanol and apply prints like Phase I, which provided a more realistic scenario. Instead, 10 Brass casings, from the random sample, were immediately treated with the best Brass sequence found. According to Phase I, this would be our second sequence. The remaining 10 Nickel casings from the random sample were treated with the fourth sequence, the best Nickel sequence found. This resulted in two large weigh boats labeled Nickel and Brass, in which Item A's did not act as controls (Table 3).

Chemical Processing

Cyanoacrylate fuming was performed in the same manner on both weigh boats for 1 h. Photographs were taken overall and of each subunit A–J, respectively with appropriate scales. Weigh boats 7:(A–E) and Brass went through the same methods as Phase I, sequence 2, in the order of: Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G. Weigh boats 7:(F–J) and Nickel went through the same methods as Phase I, sequence 4, in the order of: Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen

TABLE 3—*Phase II: list of random cartridge casings used.*

Nickel	Brass
A: 0.40	A: 0.45
B: 0.45	B: 0.45
C: 9 mm	C: 0.45
D: 0.40	D: 0.40
E: 0.40	E: 0.45
F: 0.45	F: 0.45
G: 0.40	G: Rifle
H: 9 mm	H: Rifle
i: 0.40	i: Rifle
J: 0.45	J: 0.45

Peroxide—Powder. Photographs were taken intermediate as before. Observations were made. Additionally, a CrimeScope CS-16 at 515 nm (Orange) was utilized to visualize Rhodamine 6G's effect of fluorescence upon all weigh boats. All items with fluorescing ridge detail were photographed.

Results—Phase II

Weigh Boat 7:(A–E)

Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G—Without a CrimeScope, there were no visible ridge lines on the ribbed, plastic area. However, on Item D and Item E, six and eight lines were found on the nonplastic area.

With a CrimeScope, multiple prints appeared. Item D had six overlapping prints with one having 25 visible ridge lines and *c*. 5 minutiae along with a visible core. Item E had two prints with 15 visible ridge lines with the core included.

Weigh Boat 7:(F–J)

Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder—Without a CrimeScope, there were no visible ridge lines on the ribbed, plastic area. However, On Item G, six lines were found on the nonplastic area.

With a CrimeScope, multiple prints appeared. Latent prints on Items H, i, and J were considered potentially identifiable. More specifically, one of the prints found on Item H had a visible core, delta and at least seven minutiae (Fig. 2). One print from Item i had 30 visible ridge lines with at least 10 visible minutiae. In addition, one print from item J had 31 visible ridge lines with at least six visible minutiae.

Weigh Boat Brass

Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G—Without a CrimeScope, the number of visible ridge lines was not consistent. All casings were nonidentifiable with a range of 0–18 ridge lines. The best result was found when observing Item H, a Rifle casing, which had two prints with six and 12 visible ridge lines.

With a CrimeScope, Item H had five overlapping prints, many of which were able to be classified as loops. However, none of the items in the Brass weigh boat had any prints of value.

Weigh Boat Nickel

Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder—Without a CrimeScope, excluding the Nickel 9 mm casings, the range of visible ridge lines was consistently from eight to 24. The two Nickel 9 mm casings had no visible ridge lines with a "smudged" appearance along the entire area.

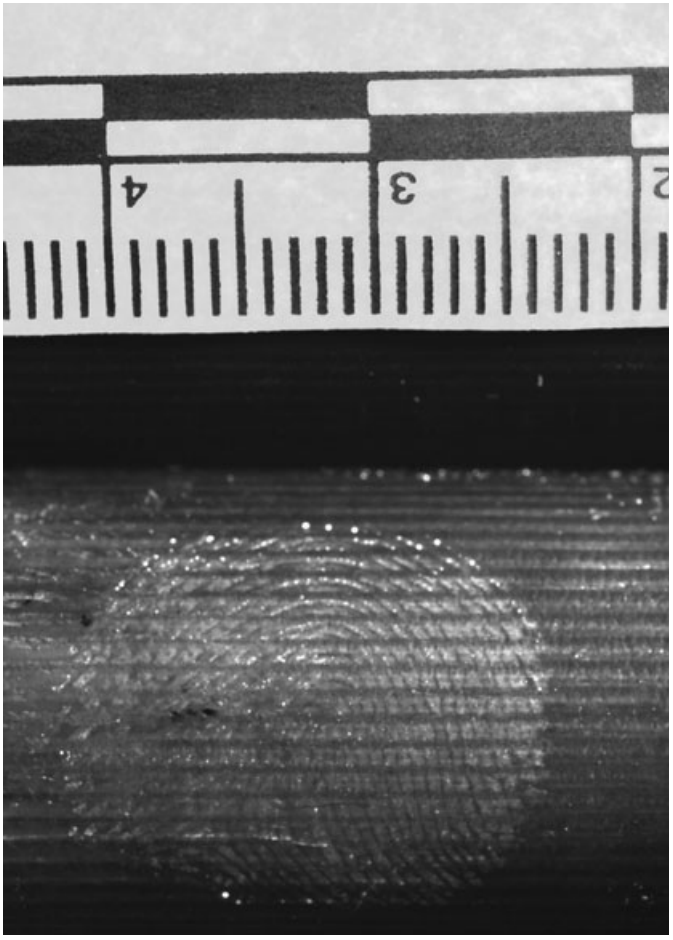

FIG. 2—*Results: subunit H (shotgun shell) of weigh boat 7 with chemical sequence: Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder.*

With a CrimeScope, the two Nickel 9 mm casings did not further develop. However, Item A, a Nickel 0.40, became potentially identifiable with an increase of five visible ridge lines and at least five additional minutiae. Item B, a Nickel 0.45, became potentially identifiable with an increase of 12 visible ridge lines and at least 12 additional minutiae (Fig. 3).

Conclusions—Phase II

Results were verified by a senior latent print examiner. Both weigh boats, 7:(A–E) and 7:(F–J) containing shotgun shells, did not have any visible ridge lines on the ribbed plastic surface until the use of a CrimeScope. However, once a CrimeScope was utilized, multiple prints appeared on items from both weigh boats. Weigh boat 7:(A–E) had two shells with potentially identifiable prints, whereas weigh boat 7:(F–J) had four shells with potentially identifiable prints. Therefore, shotgun shells had better results with the following chemical sequence, Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder, which was sequence four, the optimal sequence for Nickel casings. Again, the Brass weigh boat had overlapping prints, none of which were identifiable, but some were classifiable. The Nickel weigh boat had two items, a 0.40 and a 0.45 that were potentially identifiable with an increase

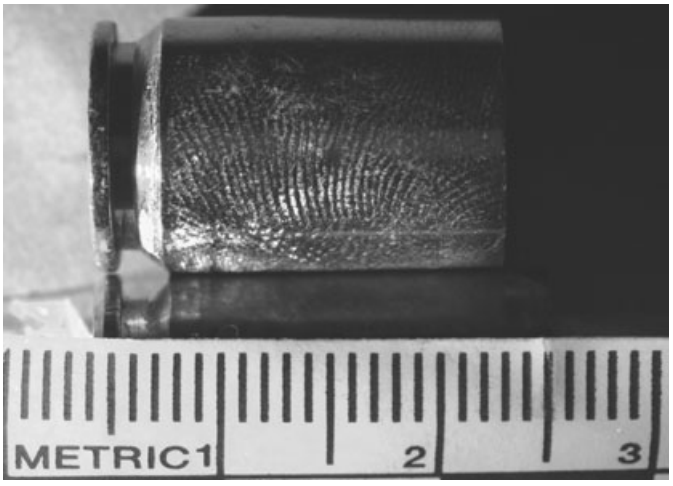

FIG. 3—*Results: subunit B (Nickel 0.45) of weigh boat Nickel with chemical sequence: Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder.*

in both visible ridge lines and minutiae, but the 9 mm casings failed to show ridge lines.

Conclusions—Overall

In order to develop latent prints, consideration should be given to the type of cartridge case being examined. In Phase I, weigh boat 2 with the chemical sequence, Cyanoacrylate—Powder—Acidified Hydrogen Peroxide—Rhodamine 6G, was determined to be the optimal sequence for Brass casings. Weigh boat 4 with the chemical sequence, Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder, was determined to be the optimal sequence for Nickel casings.

In Phase II, a random sample of Brass casings underwent the best chemical sequence found for Brass according to Phase I, with the intention of validating the second sequence as the optimal sequence for Brass casings. However, weigh boat Brass resulted in no items with prints of value. Therefore, the second sequence may or may not be the best sequence for Brass casings. Factors could be considered such as the method of donating prints. For instance, Phase I involved fresh prints of a known origin, whereas Phase II involved older prints, presumably present. Similarly, a random sample of Nickel casings underwent the best chemical sequence found for Nickel according to Phase I, with the intention of validating the fourth sequence as the optimal sequence for Nickel casings. Weigh boat Nickel resulted in two casings with potentially identifiable prints, which was an even better outcome than Phase I. Therefore, out of the six sequences tested, chemical sequence four is recommended for Nickel casings. As previously mentioned, Nickel casings were expected to produce more ridge detail than Brass casings after Cyanoacrylate fuming and post-Acidified Hydrogen Peroxide. This statement was found to be partially true. An optimal sequence was found for Nickel casings, but overall, Brass casings developed more visible ridge detail than Nickel casings.

In addition, Phase II involved shotgun shells being divided into two weigh boats such that 7:(A–E) underwent the second sequence with weigh boat Brass and 7:(F–J) underwent the fourth sequence with weigh boat Nickel. As previously mentioned, there was an expectation of little or no development on the shotgun shells. This was valid until the CrimeScope was utilized. In fact, the CrimeScope was determined to be a required tool when analyzing shells for ridge detail. The best sequence for shotgun shells was the fourth sequence, which was also the optimal sequence for Nickel casings. However, there is a limitation. The shotgun shells were only processed under sequences 2 and 4. Even though the fourth sequence provided sufficient detail, it is not necessarily the best sequence for shotgun shells.

Although limitations exist, some chemical sequences undeniably work better than others. For instance, it is recommended not to use the fifth sequence due to the best result involving only 15 faint, visible ridge lines with no minutiae. More research could be done to determine why this occurred. Perhaps, a better result could have been obtained if the sequence stopped after the second step, Acidified Hydrogen Peroxide. Perhaps, the donor did not have sufficient minutiae in that portion of their finger. Another idea is to switch Phase II around with Brass casings undergoing the fourth sequence and Nickel casings undergoing the second sequence. This could solve both the underdeveloped Brass and 9 mm Nickel casings.

Ideally, one successful method needs to be found for all types of casings and shells. According to the results of this study, the best "all around" sequence for Nickel casings, Brass casings and shotgun shells, is the fourth sequence, Cyanoacrylate—Rhodamine 6G—Acidified Hydrogen Peroxide—Powder.

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