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Latent fingerprint development from rubber gloves using MMD I (Multimetal deposition I)

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Abstract: Gloves are very important evidence at a crime scene; specifically, rubber gloves can be found easily at homes. Therefore, crime scene investigators attempt to develop fingerprints inside the rubber gloves that are discovered, for identifying unknown suspects. This study compared the effectiveness of three different methods that are used for developing latent prints on gloves with aging time. These were the powder, cyanoacrylate fuming, and multi-metal deposition I methods. The powder method achieved good results for 1–3 days of aged prints, and the cyanoacrylate fuming method worked well on 2-week-old prints. In comparison, multi-metal deposition I method developed good quality fingerprints for 6 weeks of aging time.

Key words: Colloidal gold, Multimetal deposition I, rubber glove, Fingerprint

1. Introduction

Fingerprinting is commonly used as a powerful personal identification tool in criminal investigations. Such knowledge could be exploited by criminals; for example, wearing gloves ensures that fingerprints are not left in the crime scene.[1]

Rubber gloves are commonly found, and fingerprints often remain on the surface of gloves as the hands touch the gloves when putting them on. However, rubber gloves have a rough surface, unlike glass and plastic, which makes it very difficult to develop fingerprints from rubber gloves.[2]

Hunter (1997) from Metro Nashville Police Department worked on a 25-year-old unsolved case and identified the perpetrator by using a Coomassie blue reagent to successfully develop a blood-stained fingerprint from the inner surface of a rubber glove that was suspected to have been worn by the perpetrator during the crime. The author reported that the fingerprint disappeared within 2 min when the reagent was applied for the first time, making identification impossible. However, the fingerprint was successfully developed by repeated staining.[3] Rinehart (2000) developed the fingerprint left on a rubber glove found at the actual crime scene using the cyanoacrylate (CA) fuming method and performing post-treatment with a ninhydrin-heptane carrier solution to successfully enhance identifiability of the fingerprint.[4] Sharma (2008) prepared reagents by mixing four different

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components (pryene, celite, silica, cornstarch, and iron powder) in different ratios and developed latent fingerprints from a rubber glove using one of the reagents.[5] Badiye (2015) used Robin® powder blue on various substrates, including rubber gloves, and was successful in developing latent fingerprints on all surfaces except rubber gloves.[6] Park (2016) conducted a comparative experiment, wherein the black gelatin lifter transfer method was applied after RTX and CA fuming on rubber gloves with fingerprints left up to 28 days earlier. The results showed that using the black gelatin lifter transfer method after CA fuming was more effective in developing fingerprints than RTX fuming.[7]

The results of previous studies demonstrate that developing fingerprints on the surface of rubber gloves is difficult, and despite attempts with various methods, noteworthy development results have not been presented. Accordingly, we conducted fingerprint development experiment on rubber gloves, based on MMD I which is effective on surfaces, such as semi-porous surfaces, from which developing fingerprints is difficult.

Multimetal deposition (MMD) is a technique used for developing fingerprints by sequentially depositing gold and silver on fingerprint ridges.[2,8] Kausche (1939) also discovered that colloidal gold binds to fingerprint residues, such as proteins, amino acids, and fat[9], while a solution with dispersion of colloidal gold particles with an average particle diameter of 30 nm was prepared by Frens (1973).[10] Based on the aforementioned two articles, Saunders (1989) presented a new method called MMD I for developing fingerprints.[11] Subsequently, the composition of MMD solution has been altered to introduce MMD II and even up to MMD III/IV.[12-13]

MMD I is a two-step method. In the first step, colloidal gold solution is applied to the substrate to ensure that colloidal gold particles selectively bind to fingerprint residues such as amino acids, fat, and peptides. When a colloidal solution is applied, fingerprints appear in gray, but because such fingerprints have poor a contrast ratio with the background, a post-treatment process (second step) is necessary. In the second step, a modified PD solution is applied to the substrate to ultimately enhance the fingerprints to a dark gray color.[2,8]

To investigate effective reagents for developing fingerprints on rubber gloves, our study conducted comparative experiments using the powder, CA fuming, and MMD I methods on rubber glove substrates with fingerprints aged for 1, 3, and 5 days and 1, 2, 3, 4, 5, and 6 weeks.

2. Materials and Methods

2.1 Materials and equipment

The gloves used in the experiment were household rubber gloves (Taehwa, Korea), which were cut to 8 cm × 5 cm in size and the inner surface of the gloves was used. The powder used was Swedish black powder (SIRCHIE, USA) and the brush used was a glass fiber brush (SIRCHIE, USA). A superglue (LOCTITE, USA) was used, while MMD I was prepared using ammonium iron(II) sulfate hexahydrate (Alfa Aesar, USA), iron(III) nitrate nonahydrate, tween 20, polyethylene glycol (SIGMA ALDRICH, USA), citric acid monohydrate (EMUSRE, USA), trisodium citrate dihydrate (JUNSEI, Japan), and silver nitrate(I) (DAEJUNG, Korea).

Canon 200D (Canon, Japan) was the camera used to photograph the developed fingerprints, and a SIGMA 50 mm F2.8 EX DG lens was used.

2.2. Fingerprint types and method for leaving fingerprints

In the above experiment, fingerprints from the right thumb of a 25-year-old male were used.

Before leaving fingerprints, the hand was washed cleanly with soap and dried sufficiently. A latex glove was worn with the right hand that did not touch anything, and after sufficient sweating, the glove was removed and the fingerprint was left on the inner surface of the rubber glove after 30 min.

To compare the differences in the level of fingerprint development by each technique according to how long the fingerprint was left on the substrateand they were stored for 1, 3, and 5 days and 1, 2, 3, 4, 5, and 6 weeks in a laboratory (no direct sunlight, average temperature of 25 °C, and relative humidity of 35 ± 10 %).

2.3. Powder method

Swedish black powder was evenly distributed on the glass fiber brush, and the fingerprint was developed by brushing the fingerprint left on the rubber glove until it becomes visible.

2.4. Gelatin lifter transfer after CA fuming method[7]

The rubber glove was picked up with tongs and 3 g of superglue was placed inside the CA fuming chamber. The experiment was performed for 1 h while maintaining a temperature of 120 °C and relative humidity of 70 % – 80 %.

After fuming for 1 h, the rubber glove was stored for 24 h at room temperature with no direct sunlight and was subsequently used in the experiment.

A black gelatin lifter was applied to the fingerprint developed via CA fuming and a roller was used to press the lifter to make it stick to the fingerprint without an air layer. After 10 s, the gelatin lifter was slowly separated, and the image was photographed.

2.5. Preparation and application of MMD I reagent[2]

The MMD I reagent was prepared immediately before being applied on the rubber glove. Moreover, the edges of the rubber glove were firmly taped on the bottom of the glass dish.

2.5.1. Composition of reagent and preparation method[2]

Table 1. Colloidal gold solution's composition and manufacturing method

Colloidal gold solution
Tetrachloroauric acid trihydrate (Solution A)
Etrachloroauric acid trihydrate 1 g RO-DI water 10 mL
Sodium citrate (Solution B)
Sodium citrate tribasic dehydrate 1 g RO-DI water 100 mL
0.1M citric acid (Solution C)
Citric acid monohydrate 4.8 g RO-DI water 50 mL
Polyethylene glycol (Solution D)
Polyethylene glycol 1 mL RO-DI water 100 mL
Colloidal gold (Solution E) *Prepare the above reagents in the following order.
Solution A 1 mL ① Heat the solution A until it reaches a gentle boil. Solution B 15 mL ② Add Solution B and continue to boil the solution until it turns a port-wine color. Tween 20 5 mL ③ Turn off the heat and, while still hot, add 5 mL of Tween 20 surfactant and mix thoroughly. Solution D 10 mL ④ When sufficiently cool, add Solution D and mix thoroughly. Solution C >1 mL ⑤ Adjust the pH of the solution to 2.7 by adding Solution C. RO-DI water 1000 mL

2.5.2. MMD I method

Pouring the first solution (solution E: colloidal gold solution) on the glass dish with the test substrate secured to the bottom, the dish was stirred and observed under the fingerprint developed. Once the fingerprint was developed, the colloidal gold solution was discarded and deionized water was used for several rounds of rinsing until there was no remaining colloidal gold solution. Subsequently, the second solution (modified PD solution) was poured on the glass dish and was stirred until the fingerprint was enhanced to a darker color. After the fingerprint was enhanced, the modified PD solution was discarded immediately and deionized water was used for several rounds of rinsing until there was no remaining modified PD solution. The substrate was removed from the glass dish and dried between 21 °C to 23 °C.[2]

2.5.3. Photographing

Prints were photographed under white light with camera settings of F/11 and ISO 400.

2.5.4. Fingerprint evaluation

As evaluators, 35 forensic science majors who

Table 2. Modified physical developer solution's composition and manufacturing method

Modified PD[a)] solution
Silver nitrate (Solution F)
Silver nitrate 20 g RO-DI water 100 mL
Modified redox (Solution G)
Ferric nitrate nonahydrate 16 g Ferrous ammonium sulfate hexahydrate 44 g Citric acid monohydrate 11 g Tween 20 0.25 mL RO-DI water 1000 mL
Modified PD (Solution H) *Prepare the above reagents in the following order.
Modified PD redox (Solution G) 990 mL Silver nitrate (Solution F) 10 mL

a) physical developer

studied forensic science for at least one year were selected. The fingerprints developed by the powder, CA fuming, and MMD I methods were evaluated according to the Home Office grading system shown in *Table* 3.

Home Office grading system is a visual evaluation scale used for comparing the efficacy of fingerprint development techniques, and the developed fingerprints are graded on a scale of 0 to 4 points. A higher grade indicates more distinct fingerprint ridges.[8]

3. Results and Discussion

Table 4 shows the results of fingerprints developed by the powder, CA fuming + gelatin lifter transfer, and MMD I methods according to aging time.

Table 5 shows the fingerprint development scores based on the Home Office grading system in *Table* 3 using fingerprints left on rubber gloves that were developed by the powder, CA fuming + gelatin lifter transfer, and MMD I methods. *Fig.* 1 is a graph of such scores. Fingerprints developed by the powder and CA fuming + gelatin lifter transfer methods showed a decrease in evaluation scores as aging time increased. In contrast, fingerprints developed by the MMD I method maintained relatively consistent evaluation scores, regardless of the aging time.

Analysis of variance (ANOVA), a technique for mean comparisons, was performed to look for significant difference in the fingerprint development results obtained by the powder, CA fuming + gelatin lifter transfer, and MMD I methods. As the objective of our study was to investigate which technique is effective in developing aged fingerprints from rubber gloves, not all evaluation scores were used. Instead, only the scores for fingerprints developed after 5 and 6 weeks of aging time were used. Data analysis was performed using SPSS 18.0 with the significance level set to 1 %.

As shown in *Table* 6, there were statistically significant differences in the fingerprint development scores between the MMD I and powder methods at a significant probability of $p<.01$. In addition, there were statistically significant differences in the fingerprint development scores between the MMD I and CA fuming + gelatin lifter transfer methods at a significant probability of $p<.01$.

According to *Table* 4, rubber gloves have a semi-porous surface, and consequently, the components of fingerprints are absorbed by the surface over time. The powder method is based on the principle of development by the powder particles adhering to the components of fingerprint present on the surface; as a result, the powder does not react with components

Table 3. Home Office's grading system

Grade	Level of Development
0	No development
1	Signs of contact but less than 1/3 of continuous ridges, poor contrast
2	1/3 - 2/3 of continuous ridges, adequate contrast
3	More than 2/3 of continuous ridges but not quite a 'perfect' fingermark, good contrast
4	Full development; whole fingermark, continuous ridges, excellent contrast

Table 4. After depositing fingerprints on rubber gloves, powdering, gelatin lifter after CA fuming, and MMD I were applied to rubber gloves that were aged from 1st to 6th weeks

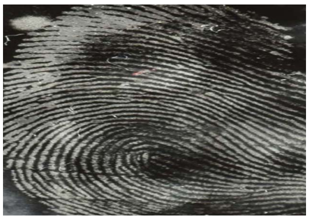
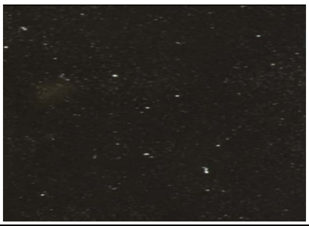
Time \ Method	Powdering	Gelatin lifter after CA fuming	MMD I
1 day			
2 weeks			
4 weeks			
5 weeks			
6 weeks			

Table 5. The mean and standard deviation of the evaluated scores by Home Office grading system

Time \ Method	Powdering	Gelatin lifter after CA fuming	MMD I
1 day	3.8	3.7	3.6
1 week	1.3	3.3	3.5
4 weeks	1.0	2.0	3.2
5 weeks	0.5	0.9	3.5
6 weeks	0.0	0.0	2.9

that have penetrated through the surface. This is probably the reason it was difficult to develop fingerprints from the surface of rubber gloves when the fingerprints had been left for 5 days or longer.[14] In addition, powder method compared to MMD I method, the powder particles used in the powder method had a diameter of 95 μm, whereas the metal particles used in the MMD I method had an average

Table 6. The results of fingerprint manifestation of powdering, gelatin lifter after CA fuming, and MMD I were compared by ANOVA (method 1: powdering, method 2: gelatin lifter after CA fuming, method 3: MMD I)

Method (I)	Method (J)	Mean difference (I-J)	Standard error	Significance probability	99 % confidence interval Lower	99 % confidence interval Upper
1	2	-.167	.113	.306	-.50	.17
	3	-2.970*	.113	.000	-3.30	-2.64
2	1	.167	.113	.306	-.17	.50
	3	-2.803*	.113	.000	-3.14	-2.47
3	1	2.970*	.113	.000	2.64	3.30
	2	2.803*	.113	.000	2.47	3.14

*<.01

diameter of 30 nm, meaning a difference of approximately 3,000× in particle size. Therefore, it is suspected that the MMD I method with finer particles was able to develop fingerprints with relatively older components compared to the powder method.

In contrast, the CA fuming method showed superior fingerprint development results compared to the powder method for fingerprints aged 5 days. This is probably because the powder method has difficulty developing aged fingerprints due to loss of moisture on the fingerprints over time, whereas the CA fuming method was able to develop fingerprints as the method involves supply of moisture inside the chamber that help trigger CA polymerization while maintaining humidity for fingerprint development.[8] However, even the CA fuming method showed difficulties in developing fingerprints aged 5 weeks or longer. This is probably because the CA polymers applied to aged fingerprints became relatively translucent as compared to those applied to fresh fingerprints; as a result, the visible contrast between the ridges and background reduced considerably.[2]

4. Conclusions

Our study compared the development effects on fingerprints left on the inner surface of rubber gloves among the powder, CA fuming + gelatin lifter transfer, and MMD I methods. There have not been many studies on methods for developing fingerprints left on rubber gloves; most previous studies have been limited only to experiments on relatively fresh fingerprints. Accordingly, our study allowed the fingerprints to age over time and compared the sensitivity of fingerprint development techniques for aged fingerprints.

For relatively fresh fingerprints (1, 3, and 5 days and 1 week), the powder, CA fuming, and MMD I methods produced similar level of fingerprint development. However, for fingerprints aged 2 weeks or longer, the MMD I method showed superior development results compared to the powder and CA fuming methods. In particular, the quality of fingerprints aged 5 or 6 weeks developed by the powder and CA fuming methods was poor. Accordingly, the experimental results indicated that the powder and CA fuming methods have limitations in developing aged fingerprints from rubber glove surfaces.

The MMD I method was able to produce very high-quality fingerprints even when they had been aged for 6 weeks. Unlike the powder or CA fuming method, the MMD I method is based on an immersion method with the substrate immersed in a solution for fingerprint development. Large quantities of gold nanoparticles in the solution react with fingerprints residue left on the rubber glove surface and residues that have been absorbed inside, which may be the reason why the level of fingerprint development was superior compared to the powder and CA fuming methods. However, the evidence for this has not been clearly identified in previous studies; consequently, future studies are needed.

The experimental results above confirmed that the MMD I method could be applied to effectively develop fingerprints from rubber gloves, even if the fingerprints are aged 6 weeks. Compared to previous studies, our study was significant in that it attempted to identify a more effective technique for developing aged fingerprints by increasing the aging time of fingerprints left on rubber gloves to 6 weeks and that it produced excellent results from applying the MMD I method, which is one of the fingerprint development techniques not commonly used in Korea. However, the MMD I is more expensive and time-consuming compared to other fingerprint development techniques; it also requires a high level of skill on the part of the user.

However, it is believed that applying the MMD I method could be meaningful for developing fingerprints left on the surface of rubber gloves collected at the crime scene, even if the crime scene is old.

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References

1. B. Fisher and D. Fisher, 'Technique of Crime Scene Investigation', 8th Ed., CRC Press, Florida, 2004.
2. R. Ramotowski, 'Lee and Gaensslen's Advances in Fingerprint Technology', 3rd Ed., CRC Press, Florida, 2012.
3. J. Hunter, *Int. J. Fingerprint Soc.*, **23**(89), 91-93 (1997).
4. D. Rinhehart, *J. Forensic Ident.*, **50**(5), 443-446 (2000).
5. K. Sharma, G. Kannikanti, T. Baggi and J. Vaidya, *Methods Appl. Fluoresc.*, **6**(3) (2018).
6. A. Badiye and N. Kapoor, *Egypt. J. Forensic Sci.*, **5**(4) 166-173 (2015).
7. J. H. Park, J. Y. Ki and S. J. Kim, *Kor. Pol. J. CSI*, **1**(1) 49-58 (2016).
8. S. Bleay, V. Sears, R. Downham, H. Bandey, A. Gibson, V. Bowman, L. Fitzgerald, T. Ciuksza, J. Ramadani and C. Selway, 'Fingerprint Source Book v2.0 (second edition)', Home Office, London, 364-377, 2017.
9. G. Kausche and H. Rusha, *Kolloid Z.*, **89**(1) 21-26 (1939).
10. G. Frens, *Nat. Phys. Sci.,* **241**(105) 20-22 (1973).
11. G. Saunders, 'Multimetal deposition technique for latent fingerprint visualization', Final Progress Report to the U.S. Secret Service, Washington, D.C., 1989.
12. N. Jones, C. Lennard, M. Stoilovic and C. Roux, *J. Forensic Ident.*, **53**(4) 444-488 (2003).
13. N. Jones, 'Metal deposition techniques for the detection and enhancement of latent fingerprints on semi-porous surfaces' PhD Dissertation, University of Technology Sydney, Australia, 2002.
14. H. I. Lee, 'New Method for Developing Latent fingerprints', ID TECH, Korea, 2002.

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