Article

Investigation into the Performance of Physical Developer Formulations for Visualizing Latent Fingerprints on Paper

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Abstract: Latent fingerprints deposited on commercial photocopy paper were treated using various preparations of silver-based physical developer and the results from each were compared to those obtained with the standard formulation used by the Australian Federal Police. Five redox stock solutions were prepared with altered orders of reagent addition, and a further solution prepared with exchanged iron concentrations, to test the robustness of the method. Three redox solutions were prepared with specific reagents omitted to determine the significance of the role played by each in development. One redox solution was prepared using Tween 20 as the non-ionic surfactant to assess its suitability as a replacement for Synperonic N. An acid prewash was also prepared using malic acid as an alternative to maleic acid. Results showed the method to be robust to alterations in reagent addition, but not to significant concentration changes. The presence of all components was found to be desirable for distinguishable development of fingerprint detail. It was additionally found that Tween 20 gave at least equal performance to Synperonic N on recently deposited fingerprints. Finally, the use of malic acid gave equivalent fingerprint development but higher background in comparison to maleic acid.

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Introduction

The type of surface on which a latent fingerprint is deposited will determine the visualization methods used. Porous surfaces, such as paper, are typically processed using amino acid-sensitive reagents, such as 1,2-indanedione and ninhydrin, both of which chemically react with the amino acids present in eccrine secretions, producing a readily visible colored complex [1, 2]. However, these methods cannot be used on wet (or previously wet) surfaces because of the loss of the water-soluble amino acids. Various development methods have been formulated to overcome this issue by instead targeting the water-insoluble sebaceous secretions of latent fingerprints.

Originally formulated to develop photographic plates, silver-based physical developer (PD) has been used as a visualization method for latent fingerprints since the 1970s [3–6]. Because it targets the more durable sebaceous secretions, PD can be used effectively on samples that have been immersed in water, as well as aged fingerprints [7, 8]. It can also be used in a sequential development process, following 1,2-indanedione and ninhydrin [9, 10]. However, the deposition of silver may cause a loss of the ridge detail developed using preceding techniques or else alter the sample and hence invalidate further analyses. The potentially destructive nature of PD highlights the importance of photographing samples following each stage of sequential processing to preserve some record of any fingerprint detail detected.

A widely used PD formulation is that developed by the United Kingdom Home Office, containing aqueous silver with a ferrous/ferric reduction-oxidation system [7]. This is stabilized by a citric acid buffer, a cationic surfactant (n-dodecylamine), and a non-ionic surfactant (Synperonic N). The ferrous ions (Fe^{2+}) reduce the silver ions (Ag^{+}) in the solution through electron transfer, causing the precipitation of colloidal silver according to the following reaction scheme:

$$Ag^{+}\,(aq) + Fe^{2+} \leftrightarrow Ag^{0}(s) + Fe^{3+}\,(aq)$$

Prior to treatment with PD, samples are subjected to an acid prewash, which removes the carbonate fillers present in the paper [6]. These fillers give copy paper a bright white appearance and a smooth finish, but interfere with PD fingerprint development unless removed. The carbonate dissolves into the working solution, increasing pH, and reacts with the aqueous silver ions to form silver oxide, turning the paper's surface black and obscuring any developed ridge detail [8, 10].

The reduction of silver ions is controlled by the citric acid and surfactants via a number of processes that have been comprehensively reviewed by Cantu [7]. Current literature suggests that citric acid maintains a low pH that suppresses formation of silver particles, while the cationic surfactant molecules form micelles about randomly formed nuclei (silver particles surrounded by adsorbed citrate anions) to prevent them from aggregating with the remaining silver ions in solution [3, 4, 11, 12]. It is thought that the non-ionic surfactant prevents the precipitation of the cationic surfactant, which is not entirely water soluble [5, 6]. However, there is evidence to suggest that the non-ionic surfactants also play a role in micelle formation, similar to the role of Tween 20 in stabilizing colloidal gold solutions [13, 14]. It is further believed that the fingerprint residue–which may develop a positive charge under acidic conditions–destabilizes the micelles, allowing the silver particles to deposit on the ridges of the fingerprint [3, 7, 15]. The resulting layer of silver grows autocatalytically, resulting in a build-up of silver on the fingerprint residue that is readily visible as a grey-black solid [7, 11].

Although a well-known and established technique, PD has seen limited use in Western Australia because of its lengthy processing time and the general perception that it is excessively difficult to prepare and use because of the instability of the working solution and the sensitivity of silver ions to contaminants. Many publications, including recent works by the Australian Federal Police (AFP), the Federal Bureau of Investigation, and the Home Office Scientific Development Branch, state that the reagents must be added in the given order of ferric nitrate, ferrous ammonium sulfate, and citric acid [3, 6, 16, 17]. However, it should be noted that early research carried out by the Atomic Weapons Research Establishment, the institute that developed the original methodology for PD, does not specify any particular order of addition for the redox stock constituents [12].

Several alternative formulations for PD have been proposed to create a more stable working solution and to reduce the concentrations of reagents required [6]. Burow suggested a formulation with reduced amounts of all components, while Yapping and Yue developed a silver ammine physical developer that did not require surfactants to stabilize the solution [18, 19]. Difficulties in reproducibility have prevented these modified physical developers finding widespread use [20].

Issues have also arisen regarding the use of Synperonic N as a non-ionic surfactant in PD, because recent studies have shown it to be a persistent environmental pollutant with oestrogenic effects [21, 22]. Subsequently, it is no longer produced commercially in Europe, where it was the primary non-ionic surfactant used for chemical and industrial purposes [21]. A recently reported formulation, used by the United States Secret Service (USSS), substitutes Tween 20 for Synperonic N and also incorporates malic acid in replacement of maleic acid for the prewash stage [14]. The new formulation also decreased the amount of surfactants used, following the replacement of distilled water with higher purity reverse osmosis deionized water [23]. Initial results indicated that this formulation gives at least equal, if not better, performance compared to the original formulation. Working solutions prepared using Tween 20 also have a longer shelf-life compared to solutions prepared using Synperonic N, possibly because of the larger Tween 20 molecules forming a thicker micelle layer and so more effectively preventing the aggregation of randomly formed silver nuclei in solution [14]. Thus far, Tween 20 appears to be the best known substitute for Synperonic N [3, 14].

In this paper, we present the results of an investigation into PD as a latent fingerprint development method in the Western Australian context in light of this recent work into formulations described above. This study aims to investigate the robustness of the PD method to develop latent fingerprints on paper through the following objectives:

- To determine the significance of the role played by various components of the PD formulation.
- To assess the suitability of Tween 20 as a stable and environmentally nontoxic alternative to Synperonic N in the PD formulation.
- To assess the comparative performances of malic and maleic acid in the preparation of paper samples for PD treatment.

The knowledge gained through this research will give forensic investigators in Western Australia a clearer understanding of how the PD method works and indicate paths that will make the method more reliable in the future. This research also endeavored to address the negative perception of PD within the forensic community and demonstrate its practicality for developing latent fingerprints on paper.

Materials and Method

Chemicals

Concentrated nitric acid (Ajax Finechem, Australia), maleic acid (APS Chemicals, Australia), silver nitrate (Chem-Supply, Australia), ferric nitrate (Chem-Supply, Australia), ferrous ammonium sulfate (Ajax Finechem, Australia), n-dodecylamine acetate (Optimum Technology, Australia), Synperonic N (Optimum Technology, Australia), Tween 20 (Sigma-Aldrich, Australia) and malic acid (Sigma Aldrich, Australia) were all used as received and were of analytical reagent grade unless otherwise stated.

Preparation of Reagents

All containers used for reagent preparation and storage were washed with concentrated nitric acid followed by a rinse with deionized (DI) water to prevent contamination of the stock solutions (which could result in premature silver deposition during fingerprint development). Reagent solutions were prepared according to the method described by the AFP [16]. The four primary stock solutions prepared were maleic acid prewash (6.25 g malic acid in 250 mL DI water), surfactant stock (0.5 g Synperonic N and 0.5 g n-dodecylamine acetate in 125 mL DI water), silver nitrate stock (10 g silver nitrate in 50 mL DI water), and redox stock (in order: 7.5 g ferric nitrate, 20 g ferrous ammonium sulfate, 5 g citric acid, and 10 mL standard surfactant stock in 225 mL DI water). Silver nitrate stock was prepared and stored in foil-wrapped glassware because of the photosensitivity of the solution. Modified solutions for comparative testing were prepared using variations of the standard stock solutions, as per Table 1. Chemical weights and solvent volumes of the modified solutions were identical to standard formulations, unless otherwise stated. pH measurements of redox solutions were conducted using an Orion 420A pH meter.

Solution	Constituents (in order added)	Alterations to Standard Formulation
Redox Solution 1 (standard AFP formulation)	Ferric nitrate, ferrous ammonium sulfate, citric acid, standard surfactant	None
Redox Solution 2	Ferric nitrate, citric acid, ferrous ammonium sulfate, standard surfactant	Change in order of reagent addition
Redox Solution 3	Ferrous ammonium sulfate, ferric nitrate, citric acid, standard surfactant	Change in order of reagent addition
Redox Solution 4	Ferrous ammonium sulfate, citric acid, ferric nitrate, standard surfactant	Change in order of reagent addition
Redox Solution 5	Citric acid, ferric nitrate, ferrous ammonium sulfate, standard surfactant	Change in order of reagent addition
Redox Solution 6	Citric acid, ferrous ammonium sulfate ferric nitrate, standard surfactant	Change in order of reagent addition
Redox Solution 7	20 g Ferric nitrate, 7.5 g ferrous ammonium sulfate, citric acid, standard surfactant	Change in concentrations of ferric nitrate and ferrous ammonium sulfate
Redox Solution 8	Ferric nitrate, ferrous ammonium sulfate, standard surfactant	Omission of citric acid
Redox Solution 9	Ferric nitrate, ferrous ammonium sulfate, citric acid	Omission of both surfactants
Redox Solution 10	Ferric nitrate, ferrous ammonium sulfate, citric acid, 10 mL surfactant 2	Omission of n-dodecylamine
Redox Solution 11	Ferric nitrate, ferrous ammonium sulfate, citric acid, 10 mL surfactant 3	Substitution of Tween 20 for Synperonic N
Surfactant 1 (standard AFP formulation)	0.5g Synperonic N, n-dodecylamine	None
Surfactant 2	Synperonic N only	Omission of n-dodecylamine
Surfactant 3	0.5 g Tween 20, n-dodecylamine acetate	Substitution of Tween 20 for Synperonic N
Maleic acid	6.25g Maleic acid	
Malic acid	6.25g Malic acid	Substitution of malic acid for maleic acid

Table 1

Physical developer stock solutions prepared for testing.

Deposition of Fingerprints

Latent fingerprints were collected from twelve donors over the duration of the testing period. Latent fingerprints were collected on Fuji Xerox Professional commercial photocopy paper. Donors were asked to rub the fingers of both hands over their foreheads to obtain fingerprints "charged" with sebaceous secretions. Each donor was then instructed to lightly touch the middle three digits of each hand onto a sheet of paper. Uncharged fingerprints were collected by instructing donors to deposit fingerprints without charging. Each set of fingerprints was given an alphanumeric label for recording purposes. Depletion series were obtained by requesting that donors deposit five sets of latent fingerprints sequentially without "recharging" the secretions on the fingertips. Latent fingerprints were treated between 1 day and 4 weeks after collection. Each set of fingerprints was divided into halves, which were then developed using different solutions for comparison.

Sample Treatment

PD working solutions were prepared by slowly adding 2.5 mL of silver nitrate stock to 47.5 mL of redox stock while stirring. All working solutions were prepared and kept in foil-wrapped glassware because of photosensitivity of the solution. Latent fingerprints were processed according to the method as described by the AFP [16]. Samples were rinsed in DI water to remove water-insoluble impurities, followed by immersion in the acid prewash for 20 to 30 minutes. Samples were again rinsed in DI water to remove any residual ions and then were treated in the working solutions until adequate contrast was achieved or otherwise for 20 minutes. The treated samples were rinsed to remove residual working solution and then were air-dried away from direct light.

Comparison Between Modified Redox Solutions and Standard Formulation

Several comparisons were conducted between the standard AFP redox solution formulation and redox solutions prepared by adding components in different orders to the standard formulation, a formulation containing exchanged concentrations of ferrous ammonium sulfate and ferric nitrate, and a formulation omitting citric acid (Table 1). Fingerprint samples were halved and treated with (1) the standard PD method and (2) a modified PD formulation.

Surfactant Testing

Comparisons were conducted between the standard AFP redox solution formulation, containing Synperonic N and n-dodecylamine acetate, and modified redox solutions prepared with modified detergent stock solutions containing Synperonic N only, n-dodecylamine only, a formulation containing Tween 20 in place of Synperonic N, and a redox solution omitting both surfactants (Table 1). Fingerprint samples were halved and treated with (1) the standard PD method and (2) a modified surfactant formulation.

Comparisons Between Maleic and Malic Acid Prewashes

Comparisons between maleic acid and malic acid pretreatments (Table 1) were conducted by halving fingerprints and immersing in (1) maleic acid and (2) malic acid for 20 to 30 minutes prior to treatment with the standard AFP PD method. Charged and uncharged fingerprints were used in these comparisons, as well as in the depletion series of charged fingerprints.

Evaluation of Results

Treated fingerprints were graded based on the quality of friction ridge detail developed and level of background development of the sample. A 5-point system (Table 2) was used, based on that developed by the United Kingdom Home Office Scientific Development Branch [24].

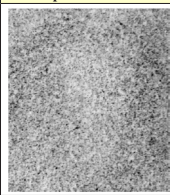
Grade	Friction Ridge Detail Development	Background Development	Photographic Representation
0	No development	Heavy background	
1	Signs of contact, but less than 1/3 of fingerprint continuous ridges	Heavy background	
2	1/3 – 2/3 of fingerprint continuous ridges	Medium background	
3	More than 2/3 of fingerprint continuous ridges, but not quite a "perfect" fingerprint	Very light background	
4	Full development; whole fingerprint, continuous ridges	No appreciable background	

Table 2

Latent fingerprint development grading system used in this study.

Digital Recording

All treated samples were photographed using a Nikon D300 camera on manual exposure mode, using a 60 mm lens. The camera was mounted overhead on a Firenze Mini Repro camera stand, illuminated by dual incandescent light globes on each side. All treated samples were photographed using a shutter speed of 1/50 seconds, aperture of F8, ISO of 200, and incandescent white balance. Samples were digitally captured on a desktop computer using the Nikon Camera Control Pro program (version 2.0.0). Photographed samples were stored in paper envelopes, out of direct light.

Results and Discussion

Preliminary Considerations

Fingerprints are not absolutely reproducible, with many factors affecting their detectability and detectable lifetime [10, 25]. These may include the composition of latent residues or quantity of material deposited (which may depend on factors such as age, gender, or diet), the amount of pressure used to apply deposits, the nature of the receiving surface, environmental conditions, and the method used to develop the fingerprint. Consequently, experimental results involving fingerprints will inevitably show some degree of variation. In this study, a number of parameters were fixed; all fingerprints were collected on the same substrate, stored under the same environmental conditions, and treated using the same established method. However, natural variation in the deposits still caused some disparity in results achieved using different fingerprints.

Comparison Between Modified Redox Solutions and Standard Formulation

The performance of the standard AFP PD formulation was compared with formulations prepared using differing orders of reagent addition, exchanged concentrations of Fe^{2+} and iron Fe^{3+}, and the omission of the citric acid buffer. Comparison tests conducted in triplicate showed no significant differences in performance between the AFP redox solution and any of the modified redox solutions 2 through 6, indicating that the order in which constituents of the redox solution are added does not actually impact on fingerprint development. Examples of the results achieved are provided in Figures 1 and 2. These results run contrary to current literature, which states that components must be added to the redox solution in the set order of ferric nitrate, ferrous ammonium sulfate, and citric acid, followed by the surfactants.

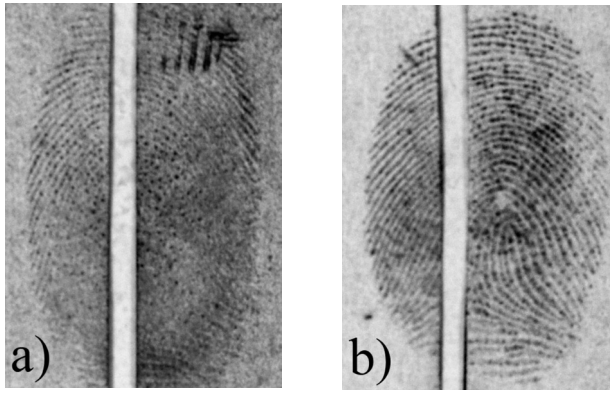


Figure 1

Latent fingerprints on photocopy paper, with split halves treated using (a) standard AFP redox solution (left) vs redox solution 2 (right); and (b) standard AFP redox solution (left) vs redox solution 4 (right).

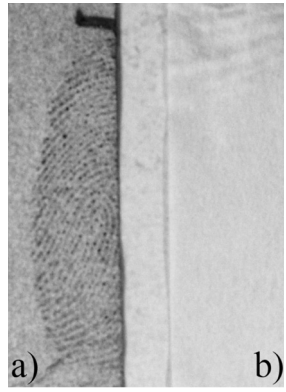


Figure 2

Latent fingerprint on photocopy paper, where halves were treated with (a) standard AFP redox solution and (b) modified solution 7, with reversed iron salt concentrations.

The specific order in which components must be dissolved in the redox solution is ostensibly designed to avoid these reagents interacting to interfere with the concentrations of Fe^{2+} and Fe^{3+} required for silver reduction [7]. Ferric nitrate is added first to avoid oxidation of Fe^{2+} (which may occur in a high concentration of Fe^{3+}, such as when ferric nitrate is added to a solution of ammonium ferrous sulfate). Any $Fe(OH)_3$ that may form in solution is then dissolved upon the addition of citric acid. Although the reasoning behind the order of addition is sound, deviating from this sequence does not appear to affect reagent performance in any way. However, standard laboratory practice necessitates a consistent procedure for preparation of the redox solution, and so the addition order should remain followed.

It should also be noted that the addition of iron salts to the redox solution causes the solution temperature to decrease slightly, which may impact on the efficacy of the working solution [7].[1] However, because the solutions were usually prepared at least one day ahead of use, any changes to solution temperature that may have occurred during preparation were not thought to affect the results of this study.

Fingerprint development did not occur when the relative concentrations of Fe^{2+} and Fe^{3+} were exchanged. Although moderately continuous ridge development was achieved using the standard AFP formulation (Grade 2), treatment with modified redox solution 7 gave no development of ridge detail or sample background (Grade 0), as seen in Figure 2.

Fingerprints treated without citric acid showed stronger development in comparison to those treated with the AFP formulation; however, there was also a high level of background development that obscured portions of the ridge detail, as seen in Figure 3. Development with the citric-omitted solution also appeared patchier, with less continuous ridge detail. Consequently, the modified solution gave an average fingerprint grade of only 1.1, in comparison to an average 1.3 using the standard formulation.

[1] An unpublished report (Barford, A. D.; Brennan, J. S.; Hooker, R. H.; Price, C. J. Home Office Forensic Science Service, Serious Crimes Unit, London, U.K. Operational Experiences in the Use of Physical Developer for Detecting Latent Marks. Unpublished work, circa 1990) brought to our attention by one of the reviewers noted that the addition of ferrous ammonium sulfate can cause a drop of 2 to 3 ℃elsius and cause other chemicals to fall out of solution. These undissolved particles could destabilize the working solution once the silver nitrate is added. The authors recommended that the temperature range of the redox solution should remain between 17–23 ℃ (63–73 ℉) at all times during the mixing process. If the temperature falls below 17 ℃ (63 ℉), some of the chemicals may precipitate out of the solution.

These results are consistent with the PD development mechanisms previously described by Cantu that detail the role of citric acid in the control of silver deposition [7]. The acidity of the standard solution (pH 1.50) was found to differ from the modified solution (pH 2.19). This may confirm current hypotheses that the silver deposition in PD is at least partially pH controlled [6]. In general, although stronger fingerprint development may occur with the omission of citric acid from the redox solution, experimental data indicates that its presence is desirable to establish distinguishable ridge detail for forensic comparison.

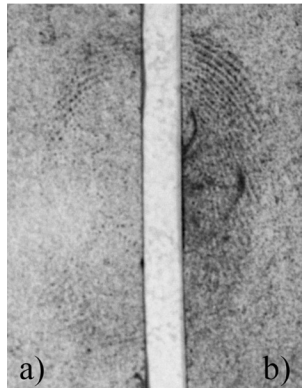


Figure 3

Latent fingerprint on photocopy paper, where halves were treated with (a) standard AFP redox solution and (b) modified solution 8, omitting citric acid.

Surfactant Testing

The second part of this study examined the effect of omitting one or both surfactants from the redox solution, as well as the suitability of Tween 20 as a substitute for Synperonic N. It was noted that the working solutions omitting n-dodecylamine or both surfactants each exhibited rapid precipitation of colloidal silver upon preparation. A modified redox solution omitting Synperonic N was also prepared, but was not tested because of the precipitation of n-dodecylamine from the stock solution within 24 hours of preparation.

The impact of omitting n-dodecylamine on the development of friction ridge detail could not be definitively established, because no fingerprint development was achieved using either the modified or AFP formulations on the samples tested (n = 5). However, it was noted that the omission of n-dodecylamine resulted in indiscriminate grey development across the entire paper surface, which could potentially have obscured any faint fingerprint development. Comparisons between the standard AFP formulation and redox solution 9 found that a greater amount of background development also occurred when both surfactants were omitted. Although one split half that was developed with standard solution showed signs of contact (Grade 1), the other half that was processed using surfactant-omitted solution gave no indications of distinguishable fingerprint development (Grade 0), as shown in Figure 4.

No significant difference was noted in the performance of redox solution 11, which substituted Tween 20 for Synperonic N, and the standard AFP PD, with all charged samples tested giving some level of development using both solutions. The level of distinguishable friction ridge detail appeared to be equivalent between both solutions (shown in Figure 5), with an average grade of 1.3 using the standard formulation compared to an average 1.2 with the substitution of Tween 20. It was noted, however, that the development appeared to be slightly stronger using Tween 20 in 3 out of 10 samples tested.

It was interesting to note that all 10 uncharged samples could be detected to some degree with both PD formulations, with an average grade of 1.8 with both the AFP and the Tween 20 formulations. Four out of 10 samples tested gave development grades of 2 or higher (Figure 6). Although PD is often described as a lipid-sensitive development method, evidence suggests that PD also interacts with large, insoluble proteins and possibly amino acids, which also become protonated in an acidic environment

[5, 14]. Because uncharged fingerprints contain minimal lipid material, these results support the hypothesis that silver deposition is triggered by nonlipid compounds in fingerprint residue.

Comparisons of the two reagents using depletion series produced similar results, with the Tween 20 formulation found to be equivalent in performance to the AFP formulation containing Synperonic N. No satisfactory fingerprint development was produced using either formulation past the second or third depletion, though some signs of contact were still evident in the fourth or fifth depletion in many samples. No significant differences in sensitivity were observed between the two formulations.

Additionally, the substitution of Tween 20 for Synperonic N appears to be more stable than the standard formulation in terms of silver precipitation. Significantly less silver formation in solution was observed with the modified solution during use, indicating that Tween 20 may be more effective than Synperonic N in this role. The increased stability of this formulation provides several advantages: less silver is wasted, potentially extending the usable lifetime of the solution; and less cleaning is required to remove residual silver from glassware. Overall, the experimental data found Tween 20 to be a feasible future alternative to Synperonic N.

Comparisons Between Maleic and Malic Acid Prewashes

Preliminary tests were conducted to compare the effectiveness of a malic acid prewash to the standard maleic acid prewash. Comparisons performed with five replicates found that pretreatment using malic acid gave equivalent fingerprint development in comparison to maleic acid, but also gave smears of high background development (shown in Figure 7) that partially obscured the ridge detail in two samples. Malic acid hence gave an inferior overall performance, with an average grade of 1 compared to an average of 1.4 using maleic acid. It was noted during testing that effervescence of samples using the malic acid prewash was much more subdued in comparison to maleic acid, which may indicate that malic acid requires a longer sample immersion time in order to be effective. The malic acid solution was also found to have a weaker acidity (pH 2.01) in comparison to maleic acid (pH 1.29). This could also indicate that the acidity of the prewash solution is influential in the removal of carbonate fillers from the paper substrate.

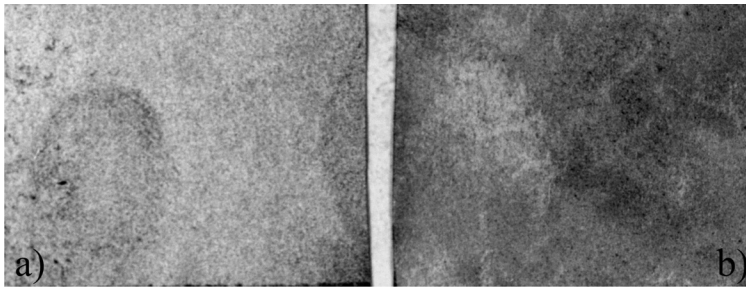


Figure 4

Latent fingerprint on photocopy paper, where halves were treated with (a) standard AFP redox solution and (b) modified solution 9, omitting both surfactants.

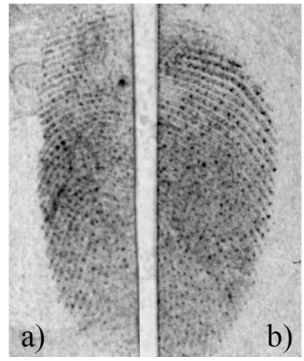


Figure 5

Charged latent fingerprint on photocopy paper, where halves were treated with (a) standard AFP redox solution and (b) modified redox solution 11, substituting Tween 20 for Synperonic N.

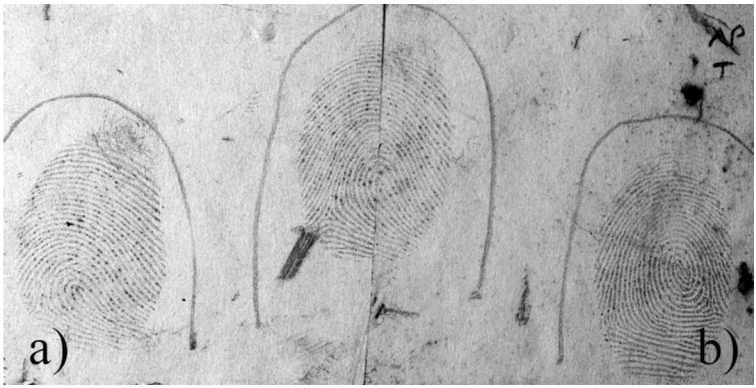


Figure 6

Uncharged latent fingerprint on photocopy paper, where halves were treated with (a) standard AFP redox solution and (b) modified redox solution 11, substituting Tween 20 for Synperonic N.

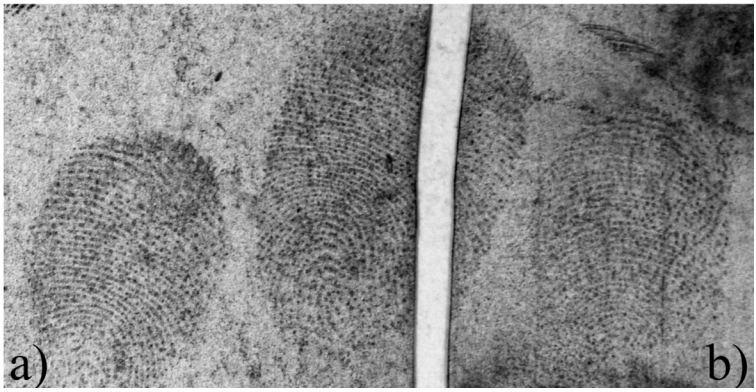


Figure 7

Latent fingerprint set on photocopy paper treated with physical developer, showing equivalent fingerprint development but less background development using (a) a maleic acid prewash, in comparison to (b) a malic acid prewash.

Conclusions

The purpose of this study was to test the robustness of the AFP PD method, to determine the significance of the roles played by various components of the formulation, and to test feasible chemical alternatives for maleic acid and Synperonic N. The results show PD to be more robust than current literature suggests. For example, there appears to be no actual requirement for a particular order of reagent addition when preparing the redox stock solution. However, significant alterations to the formulation will result in a failure to develop latent fingerprints, as may be generally anticipated for a method of chemical detection. Interestingly, PD is capable of developing both charged and uncharged fingerprints, indicating that the deposition of silver particles is not specific to lipids.

The substitution of Tween 20 for Synperonic N in the PD working solution was found to give at least equal performance in the development of recently deposited latent fingerprints on paper, compared to the standard formulation. This indicates that Tween 20 may be a suitable alternative non-ionic surfactant, in the event that Synperonic N becomes unavailable. Recent research has indicated that the performance of working solutions based on Tween 20 improve on standing for 72 hours after mixing [14]. Within the time constraints of this research project, we did not see any significant difference between solutions made fresh and those left to stand; this is currently the subject of on-going studies that will include an assessment by fingerprint examiners from the Western Australian Police.

Finally, the use of malic acid in the preparation of paper samples was found to give fingerprint development comparable with that obtained using the traditional maleic acid prewash. However, the level of background development achieved was less consistent, with some samples exhibiting background development that obscured the fingerprint ridge detail, thus giving inferior overall results. The development of latent fingerprints is still possible without the presence of an acid buffer and may still occur when one or both surfactants are omitted from the formulation. However, the quality of ridge detail–and the ability to discern this ridge detail from background development–may be greatly impaired because of the uncontrolled deposition of colloidal silver across the paper surface.

This study demonstrates that PD remains a useful and reliable method of detection for latent fingerprints on paper, thereby establishing the potential value of this technique to Western Australian forensic investigators. Despite the time taken for the full processing of samples, consistent detection of latent fingerprints was achieved up to a full month following fingerprint deposition. In scenarios where other visualization methods may fail to produce results, PD remains a valuable step in the development sequence for latent fingerprints on porous surfaces.

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