Article

Evaluation of a Solvent-Free p-Dimethylaminobenzaldehyde Method for Fingermark Visualization with a Low-Cost Light Source Suitable for Remote Locations

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Abstract: The guidelines set forth by the International Fingerprint Research Group (IFRG) were used to plan and conduct the evaluation of a dry contact *p*-dimethylaminobenzaldehyde (DMAB) approach to the treatment of latent fingermark deposits on porous substrates. It was found that the IFRG guidelines provided a practicable framework for the implementation of method optimization and comparison studies. Extensive investigations into the development method and its subsequent use across a range of conditions and substrates showed that the dry contact DMAB method is not as sensitive as the recommended ninhydrin techniques. Illumination in the form of an inexpensive LED light source was shown to be a promising alternative to the much more expensive Rofin Polilight, especially in teaching or remote environments.

Introduction

p-Dimethylaminobenzaldehyde (DMAB) is a reagent that targets the nitrogen-containing constituents (including amino acids) of fingermarks. This is consistent with the majority of

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established treatment methods that react with these compounds because of amino acids' stable and strong binding to cellulose fibers, which results in the long-lasting spatial integrity of fingermark ridge detail [1–4]. In previous work by this group [5], an inexpensive and simple approach to visualizing fingermark impressions on fragile samples that may deteriorate with wet contact methods was introduced. The technique consisted of a dry contact approach using treatment papers. To further assess this approach's robustness, sensitivity, and operational suitability, the technique required a more in-depth evaluation, the results of which are presented here.

To aid the experimental design of this study, the recent special feature report published by the International Fingerprint Research Group (IFRG) was considered [6]. In the report, guidelines are proposed by the IFRG to the best practice approach for the evaluation of novel or modified fingermark treatment options. To summarize, the evaluation process can be divided into four phases. Phase 1, or pilot studies, can be considered proof-of-concept investigations and do not require rigorous testing for this initial work. However, before the potential of a novel technique is subjected to a full validation study under pseudo-operational conditions (phase 3), it is evaluated using a larger number of donors, substrates, and other variables to satisfy the criteria of a phase 2 study. Lastly, phase 4 assessments are implemented as the final step and involve casework trials and the "inclusion into standard operating procedures" [6]. The document therefore provides a list of guidelines that may facilitate maintaining and improving the quality of studies being conducted and presented by the fingerprint research community. The continuous quest for alternative and improved methods is the primary focus of fingermark research for the practical advancement of operational casework facilities. The recently published dry contact DMAB formulation [5] can be considered as one of the aforementioned alternative treatment options at the phase 1 level, but requires phase 2 testing to evaluate its suitability for possible fingermark casework [5]. Although the results of the previous publications indicate that dry contact DMAB may not be as sensitive as established fingermark methods, it provides inexpensive, simple, solvent-free, and less harmful fingermark development, making it very amenable to deployment in remote locations. The study presented here provides a demonstration of how the IFRG guidelines can be used to assist planning and implementation of an evaluation of a potential fingermark visualization treatment.

Anecdotally, one limitation to the widespread use of luminescent fingermark reagents is the expensive nature of forensic light sources, especially in low volume forensic laboratories. It has been well established that the increased contrast and decreased background interference of luminescent fingermarks are very useful for routine police work, especially with deposits on brightly colored or patterned substrates [3]. Recent, unpublished experiments by the authors have identified an inexpensive, commercially available LED light source that is capable of causing luminescence in 1,2-indanedione-zinc chloride and DMAB-treated exhibits. Because of the low cost (US $25), robustness, and portable nature of this light source (available in a range of output colors, depending on the excitation wavelength required), a very appealing case is presented for those laboratories where more expensive and cumbersome systems are not feasible.

This study aimed to further investigate the novel dry contact latent fingermark development reagent, DMAB. With reference to the IFRG guidelines [6], this study was categorized as a phase 2 study. On this basis, experiments comprising a larger donor pool of both biological sexes at varying ages and a wider variety of substrates than in the original pilot study [5] were performed. The stability of the dry contact papers and treated samples, as well as the optimum method parameters, were established. Ninhydrin was used as a reference point for the substrate studies and the treatment of aged fingermark specimens. This is the treatment currently used operationally at the location where this evaluation was carried out. In addition to the optimization and comparison study, all images were also recorded using the alternative LED illumination to assess its practical use for fingermark casework.

Materials and Methods

Chemicals

Absolute ethanol (CSR Chemicals, Australia), acetone (Ajax Finechem, Australia), ethyl acetate (Univar Analytical, Australia), glacial acetic acid (CSR Chemicals, Australia), HFE-7100 (1-methoxynonafluorobutane, 3M Novec, Australia), ninhydrin (Optimum Technology, Australia), and *p*-dimethylaminobenzaldehyde (BDH, U.S.A.) were all used as received and were of analytical reagent grade unless otherwise stated.

Substrates

A range of substrates were investigated in the course of this study. These consisted of plain white A4 copy paper (Fuji Xerox Professional or OfficeMax 50% recycled, 80 g/m^2), newspaper, glossy paper (brochure), gift wrapping paper (various designs), Post-it notes (various colors), notebook paper, and envelopes (various colors). Thermal paper was used in the form of unprinted thermal register rolls (Officeworks, Australia) and printed receipts from several supermarkets.

Collection of Latent Fingermarks

Latent fingermarks were collected on all substrates from at least 10 donors per experiment. The hands were rubbed together prior to depositing fingermarks to offer consistent natural, uncharged fingermarks. Donors were instructed to gently place fingertips onto the substrate (less than 10 seconds overall deposition time); the fingermarks were then outlined in graphite pencil. Samples were kept in the dark for at least 24 hours prior to treatment unless stated otherwise. For the study of aged specimens, fingermarks were collected on plain white photocopy paper and kept in a darkened cupboard in controlled laboratory conditions for 6 and 18 months.

Aged Prints and Environmental Conditions

Ten donors on three different occasions deposited fingermarks on plain white copy paper. Each of the three replicates was halved and separated for treatment with DMAB or ninhydrin and further divided into controlled and semicontrolled environment groups to be aged 2, 4, and 6 weeks prior to development. The controlled conditions present from the collection date through to development were a near constant temperature of approximately 24 °C and a maintained relative humidity of approximately 50% in darkness. The climatic extremes measured by the Bureau of Meteorology, Australia, at the semi-controlled storage were 23.0 to 41.5 °C and a relative humidity range of 20 to 96% [7, 8]. Similar minimum temperatures were observed within the storage location, however, the daily maxima were about 10 °C warmer.

Preparation of Reagent Solutions

DMAB (1, 2, 4, and 6 g) was dissolved in 100 mL of ethyl acetate unless otherwise stated. The dry contact treatment papers were prepared by dipping A4 white copy paper into the working solution and allowing the sheets to air dry before storing in a sealed zip-lock plastic bag. The formulation and

application of ninhydrin utilized for this project was as per the HFE formula prescribed by the National Centre for Forensic Studies (Table 1) [9]. Dry contact ninhydrin treatment papers, for use on thermal paper, were created by dipping A4 white copy paper into the working solution and allowing the sheets to air dry before storing in a sealed zip-lock plastic bag.

Solution	Reagent Preparation
Stock Solution	36.5 g ninhydrin dissolved in 425 mL absolute ethanol, addition of 35 mL ethyl acetate followed by 40 mL acetic acid
Working Solution	65 mL stock solution is added to 935 mL HFE-7100

Table 1

Preparation of the ninhydrin stock and working solutions [9].

Development of Latent Fingermarks Using the DMAB Method

The final dry contact method consisted of either placing the samples between treatment papers in an Elna laundry press on the high temperature setting for 45 seconds (nonfragile samples) or placing the samples between treatment papers in a zip-lock bag for 5 days (fragile samples).

Sensitivity of DMAB Treatment Method

For the blind study, donors were asked to deposit between 5 to 10 fingermarks with each hand on A4-sized white copy paper. The number of marks that were deposited by each hand was noted by the donor, so that the researcher evaluating the blind study was not aware of the exact number of deposits. Three prints were collected from each hand for the depletion series, where five consecutive deposits were collected. One half of each hand was subsequently developed by DMAB and compared to the ninhydrin-treated half.

Robustness of DMAB Treatment Method

The robustness of the DMAB treatment method was evaluated by changing the following parameters. The concentration of DMAB was varied from 1, 2, 4, and 6 g per 100 mL of solvent. The contact time was varied from 2, 4, 5, 7, 10, 15, 20, 25, and 30 days. A reagent solution (consisting of 4 g DMAB in 100 mL ethyl acetate) was stored in a darkened flammables cabinet for 12 months. Sample degradation was evaluated by storing treated samples in a darkened cupboard in a temperature-controlled laboratory. Treatment papers were made fresh and stored for 0, 5, 10, 15, 20, 25, and 30 days prior to sample treatment to evaluate their stability.

Development of Latent Fingermarks Using the Ninhydrin Methods

With the exception of the thermal paper, all of the samples were immersed in the ninhydrin solution, allowing the solvent to evaporate before placing them into open A4 plastic protector sheets for development in the dark. The ninhydrin thermal receipt paper samples were treated by applying the same dry fuming method used on the DMAB samples. This involved placing the replicate between two ninhydrin treatment papers for at least 2 days.

Photography of Samples

Samples were photographed with a Nikon D300 camera, equipped with an AF-S Micro-Nikkor lens, mounted on a Firenze Mini Repro tripod and connected to a computer running Nikon Camera Control Pro version 2.0.0. Illumination in luminescence mode was achieved using a Rofin Polilight PL500 (Rofin, Australia), with an excitation wavelength filter of 490 nm (40 nm bandwidth) for the DMAB-developed marks. A 3W Cree Blue LED Mini Spot Light (Cree, Durham, NC) was used as an alternative excitation source. An orange camera filter attachment (Foster + Freeman Schott OG550, 529 nm barrier filter) was used. Illumination in absorbance mode was achieved using incandescent light with no camera filter attachments. Photographic conditions are summarized in Table 2. The images here are presented as captured, with no additional enhancement.

	Absorbance Mode	Luminescence Mode
Focal Length/ mm	60	60
Exposure Mode	Manual	Manual
White Balance	Auto	Auto
Shutter Speed/s	1/20	1
Aperture	f/11	f/11
Sensitivity	ISO 200	ISO 200

Table 2

Photographic conditions for absorbance and luminescence mode photographs.

Fingermark Evaluation

A grading system based on the Home Office Police Scientific Development Branch, United Kingdom was used for sample grading throughout (Table 3) [10]. Microsoft Excel Professional Plus 2010 was used to record the results and to calculate the mean and median values. One person graded all fingermark samples to prevent intergrader inconsistencies. A single practicing fingerprint expert was used for the same reason to determine whether treated exhibits were suitable for identification purposes.

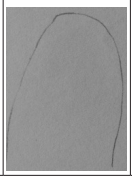
Grade	0	1	2	3	4
Friction Ridge Detail Development	No development	Signs of contact, but less than 1/3 of fingermark continuous ridges	1/3 – 2/3 of fingermark continuous ridges	More than 2/3 of fingermark continuous ridges, but not quite a "perfect" fingermark	Full development; whole fingermark, continuous ridges
Contrast of Ridge Detail and Background	No contrast	Poor contrast	Moderate contrast	Good contrast	Very good contrast
Photographic Representation					

Table 3

The fingermark grading scale used to evaluate treated exhibits.

Results and Discussion

Method Optimization

The reagent formulation that was used in the pilot study was used as the baseline for changes made to subsequent approaches [5]. Several factors affect the best possible development of fingermark samples using chemical approaches. Parameters that may be altered for dry contact methods include the composition of the reagent, the contact time, and the use of heat to provide energy for a faster reaction.

Reagent Composition

It is vital to have enough DMAB available to fully react with the amino acid target compounds to obtain well-developed ridge detail. Although using an excess of the reagent is not as problematic with dry contact methods as it is with wet contact techniques (where overdevelopment and background staining is more likely to occur), factors such as cost and waste management still have to be considered for operational use. Concentrations in the range of 1 to 6 g per 100 mL were trialed, where no difference to development was found in the higher amounts. Amounts of 1, 2, and 4 g showed similar results in stronger deposits, but overall development was decreased with 1 g (Table 4). At the lowest concentration, there was less spotting of the substrate, hypothesized to be from DMAB agglomeration that was due to the drying process. The spotting of the substrate could be further minimized by leaving the treatment papers to dry for longer periods of time. Although the background was darker and therefore better for contrast (in luminescence mode) at 1 g, ridge detail was minimized and ultimately of less use for operational purposes. Samples split and treated with 2 and 4 g showed no significant difference in ridge detail, however, the background spotting was reduced at 2 g.

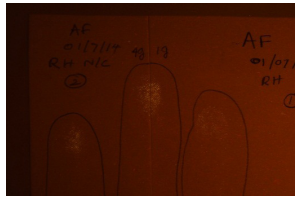
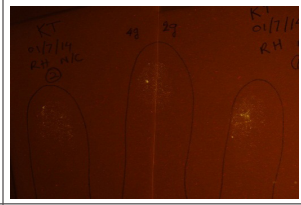
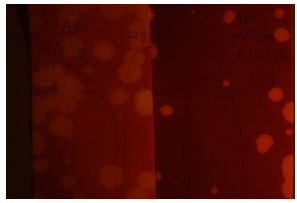
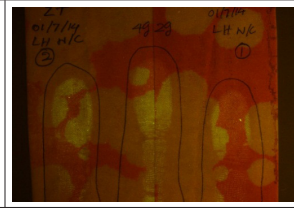
Substrate	4 g (left) vs 1 g (right)	4 g (left) vs 2 g (right)
Plain White Copy Paper		
Thermal Paper Receipts		

Table 4

Photographs of fingermark deposits treated with DMAB at 1, 2, or 4 g per 100 mL.

In addition to the concentration of DMAB, the type of solvent can have a marked effect on sample integrity and development. Because of the polarity of DMAB, nonpolar solvents cannot be used. However, because the exhibits are not dipped directly into the working solution, polar solvents should not adversely affect inks and thermal papers. Acetone, ethanol, and ethyl acetate were trialed, where ethanol resulted in less overall development. Ethyl acetate and acetone could be used with no marked difference in ridge detail. It should be noted that acetone evaporates at a lower temperature (56.2 °C) than ethyl acetate (77 °C), which does mean that the treatment papers dry quicker; however, when preparing multiple treatment papers, the working solution does also evaporate much more rapidly. The remainder of this study was therefore performed using ethyl acetate.

In the pilot study, it was found that the addition of an acid to the formulation made no observable difference to ridge detail contrast, and it was again omitted from this method [5]. This eliminates an extra preparation step and also makes the entire procedure safer and less expensive. Therefore, a working solution consisting of 2 g of DMAB per 100 mL ethyl acetate, or acetone, was found to offer a less expensive, lower waste, new formulation to that previously published [5].

Contact Time

Fingermark deposits on both white copy paper and thermal receipt paper (on used receipts and fresh thermal receipt roll) showed little further development when photographed every 5 days over a 1-month period (Table 5): Please note that the change in background color between images is thought to be an artifact of the photography caused by the automatic white balance setting. It is proposed that the spotting of the background in thermal substrates occurs because of the reagent reacting with the active layer. Over time, as the active layer is completely degraded, the background is lighter, without spots. Tests indicated that there was little difference between samples kept in contact with the treatment papers for shorter periods, where only marginal improvement to the ridge detail was observed when using prolonged contact in a 2-, 4-, 5-, and 7-day time frame. For the purposes of this study, specimens were in contact with the treatment papers at room temperature for a point of comparison.

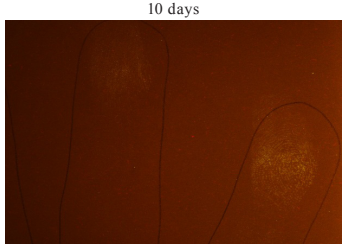
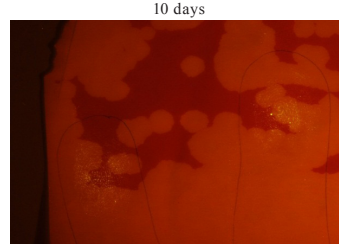
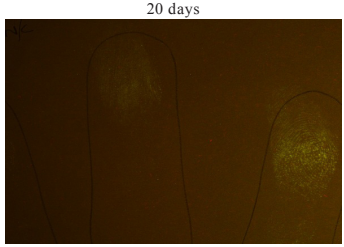
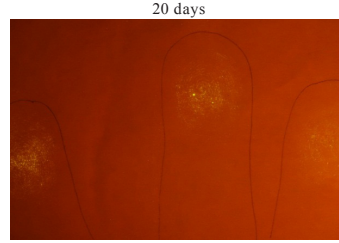
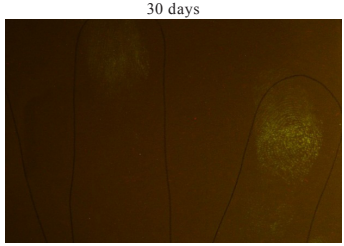
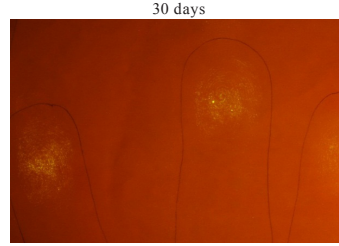
White Copy Paper	Thermal Paper
10 days	10 days
	
20 days	20 days
	
30 days	30 days
	

Table 5

Photographs of DMAB-treated fingermark deposits after extended contact periods.

Heating

Using a heat source can speed up the imine reaction, and therefore sample development occurs much more rapidly. A fingermark reagent should provide complete development as quickly as possible so as to make it more amenable for operational purposes. Because dry contact methods are often used for fragile exhibits, using heat may not be practical in all circumstances. The current method gave very good results by heating samples between treatment papers for 45 seconds in an Elna laundry press at approximately 160 °C. Alternative heating conditions were sought for fragile samples [5].

Exhibits placed between treatment papers and wrapped in aluminum foil and heated in an oven at 50 or 80 °C for 60 minutes showed improved development compared to samples in contact with treated paper kept at room temperature for 5 days (Table 6). After 24 hours, most of the ridge detail had developed, and further heating provided little benefit. Although thermal substrate degradation was less pronounced with exhibits placed in an oven at 50 or 80 °C (compared to the Elna laundry press), the oven was still found to be unsuitable for substrates sensitive to heat. For the quick and easy treatment of nonfragile samples, the Elna laundry press can be recommended. Where heat treatment is not feasible, a contact time of 2 days (or until sufficient ridge detail is visible) at room temperature should be used instead.

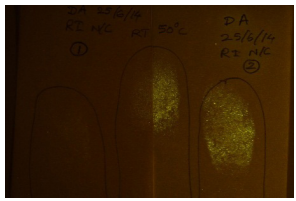
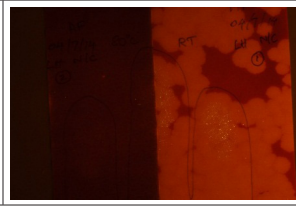
Substrate	Room Temperature (left) vs 50 °C Oven (right)	80 °C Oven (left) vs Room Temperature (right)
Plain White Copy Paper		
	50 °C Oven (left) vs Room Temperature (right)	80 °C Oven (left) vs Room Temperature (right)
Thermal Paper Receipts		

Table 6

Photographs of DMAB-treated fingermark deposits, with and without the application of heat.

Operational Considerations

The improved method was applied to a larger range of samples, because the reagent conditions tested for use on copy paper and thermal paper must also afford good development with potentially more difficult exhibits. In addition to the testing of various substrates, the method was also investigated for its robustness and use on older fingermark exhibits. Blind studies and depletion series gave an indication of the reagent's sensitivity in comparison with ninhydrin.

Substrates

A host of different porous and semiporous substrates are encountered as everyday items, including gift wrapping paper, colored paper, envelopes, post-it notes, thermal paper, filter paper, and newspaper. In this study, the response of latent fingermarks deposited on a number of these porous and semiporous substrates and treated with DMAB was compared to ninhydrin. The purpose of this was not to establish which of these methods was more sensitive, but rather to determine the efficacy of DMAB on a range of exhibits. Ninhydrin was used only as an indication of strong or weak deposits (Table 7).

The DMAB dry contact method appeared to work better on glossy, bright white, and smooth surfaces (e.g., wrapping paper and white copy paper). It is likely that the improved performance on less porous substrates occurred because of enhanced surface area contact with the treatment papers on these smoother surfaces.

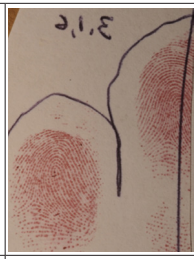
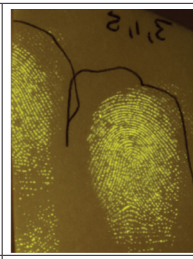
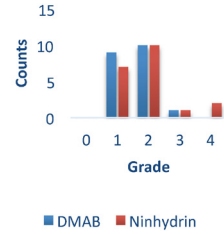
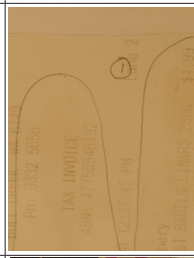
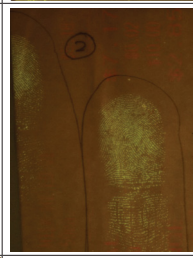
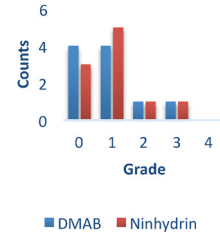
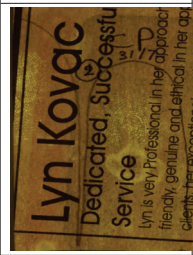
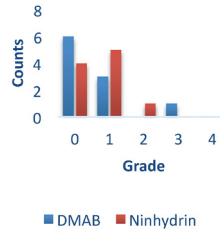
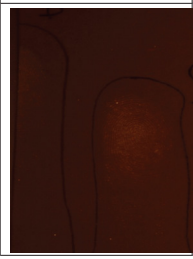
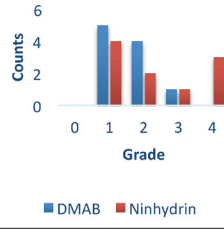
Plain White Copy Paper			
Thermal Paper Receipts			
Newspaper			
Colored Paper			

Table 7

Photographs of ninhydrin- and DMAB-treated fingermark deposits on various substrates.

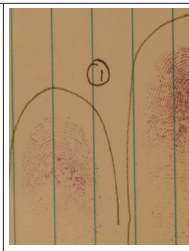
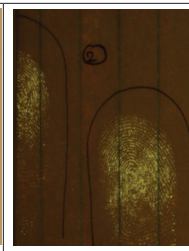
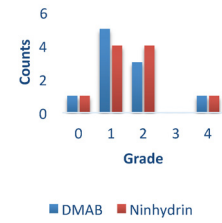
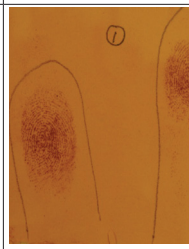
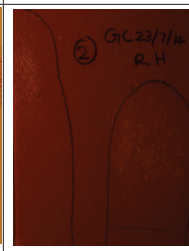
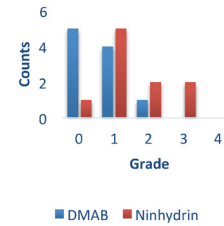
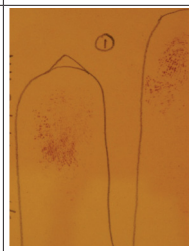
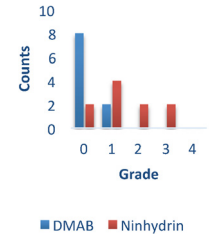
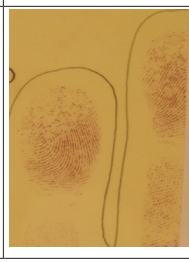
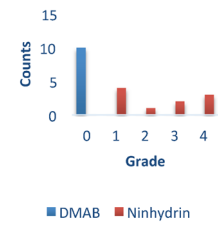
Notebook Paper			
Orange Envelope - Inside			
Orange Envelope - Outside			
Post-It Notes			

Table 7 (continued)

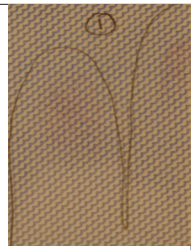
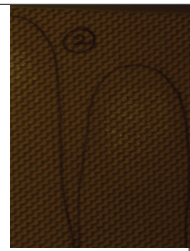
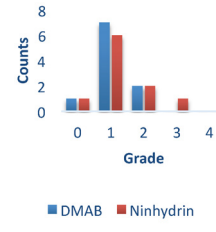
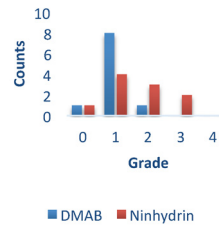
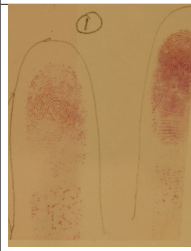
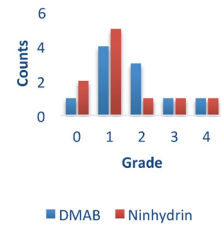
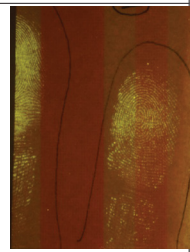
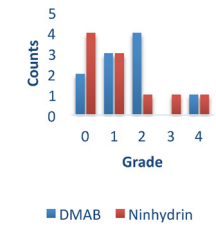
White Envelope - Inside			
White Envelope - Outside			
Wrapping Paper - Inside			
Wrapping Paper - Outside			

Table 7 (continued)

Aged Prints and Environmental Conditions

One aspect highlighted by Kent [11], as well as the IFRG [6], is that method optimization and comparison studies should consider aged fingermarks as well as relatively fresh deposits. To investigate the effect of time since deposition, fingermark specimens on white copy paper that were 6 and 18 months old were treated. Ninhydrin was again used as a point of reference, yielding samples that were less developed than the dry contact DMAB halves. Of the fingermark deposits investigated, ninhydrin achieved a mean grade of 0.5 compared to 0.8 for DMAB (median grade of 0 and 1, respectively).

In addition, a trial was conducted to simulate the effects of environmental factors that forensic exhibits may be subjected to prior to collection or treatment. Samples that had been deposited on white copy paper and left at controlled (within a climate-regulated laboratory) and semicontrolled (under cover outside) locations for 2, 4, and 6 weeks prior to treatment showed significant differences between ninhydrin and DMAB. Ninhydrin produced development on nearly all of the samples for each of the time periods and environments. A gradual downward trend in ninhydrin development was observed mainly in the semicontrolled environment, which had experienced some extreme tropical weather (from a mean grade of 2.1 to 1.7). For specimens stored in a controlled environment, the mean grade remained constant. Many of the 2-week-old DMAB-treated fingermarks displayed development (mean grade 1.3), yet this was found to be reduced after a further 2 weeks, where a more significant decrease in ridge detail was observed in the semicontrolled compared to the controlled samples (1.1 vs 1.4, respectively). In this study, none of the 6-week-old specimens showed development using DMAB. Overall, ninhydrin outperformed DMAB as a fingermark reagent for use on aged fingermark deposits under harsh environmental conditions (mean grade of 1.9 vs 0.8), indicating a more sensitive reagent (Table 8).

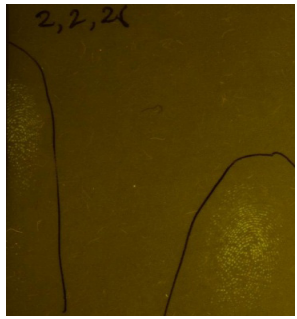
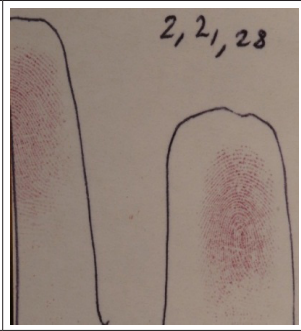
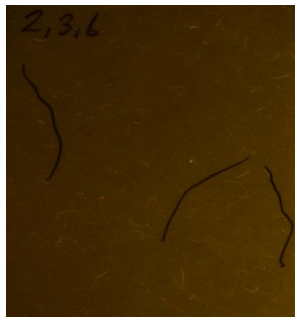
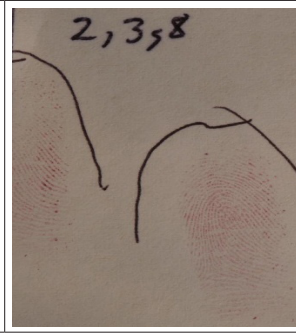
Aging period	DMAB-treated Samples	Ninhydrin-treated Samples
2 Weeks		
4 Weeks		
6 Weeks		

Table 8

Photographs of ninhydrin- and DMAB-treated fingermark deposits on white copy paper and aged for 2, 4, and 6 weeks.

Sensitivity of DMAB Treatment Method

As outlined by Kent and the IFRG guidelines, the sensitivity of a reagent can be assessed using a depletion series [6, 11]. Although amino acid-rich fingermark deposits may give a strong response even to unsatisfactory reagents, because of the decreasing amount that is transferred with each additional deposition, a depletion series can indicate reagent response when approaching the limit of detection [6]. Although development was present in nearly all the treated marks, the strength of the ridge contrast was greatly reduced from the second deposit onward. Little difference between ninhydrin- and DMAB-treated depletion series could be observed.

The IFRG guidelines also recommend blind studies as a good indication of "the ability of the technique to perform on unknown samples" and provides another point of comparison with established methods [6]. This group has previously used blind studies in evaluation studies of a dry contact 1,2-indanedione method, and the same approach was therefore implemented in the current report [12]. In this case, all of the ninhydrin reference specimens gave 100% agreement of displayed versus the actual number of marks deposited. The dry contact DMAB method also gave a success rate of 100%; however, the very weak deposits were much harder to discern and only a very faint impression could be observed.

Robustness of DMAB Treatment Method

The robustness of any technique, whether new or altered, is imperative for the routine employment by law enforcement personnel. Ideally, a method should work even if its parameters, such as concentration or contact time, are changed slightly by the user [13]. In this regard, the dry contact DMAB procedure was observed to offer similar levels of development, whether a concentration of 2 to 6 g per 100 mL solvent was used and at a range of contact times, from 2 to 30 days.

Other aspects to consider when developing a new or altered reagent formulation are the working shelf life of treated fingermark exhibits, the working reagent solution, and the treatment papers (in the case of dry contact methods), and that these are stable for extended periods of time. Because it may not always be possible to photograph ridge detail immediately following treatment, it is of importance that the reaction product is stable. Samples photographed every 5 days over a 1-month period after treatment indicated that little degradation had occurred.

A 12-month-old working solution also provided very similar levels of development compared to the fresh formulation, with no appreciable loss in intensity. Lastly, treatment papers that had been stored in zip-lock bags for 5 to 30 days once again revealed indistinguishable results to fresh treatment papers. These experiments indicate the dry contact DMAB method to be a robust, practicable technique, amenable to routine implementation.

Samples Suitable for Identification Purposes

The IFRG guidelines recommend for phase 3 and above that some measure of how many developed marks are suitable for identification be determined [6]. Although the study presented here is clearly at an earlier stage in the evaluation process, the suitability for identification of the DMAB-treated marks on a variety of substrates was compared by a fingerprint expert to those developed with ninhydrin. This assessment was performed on alternative substrates to plain white copy paper, because developed marks are potentially more difficult to visualize on these surfaces. The results are summarized in Table 9. As can be seen from the data presented, although there may be some similarity in the mean grades on some substrates, this does not necessarily correspond to suitability for identification. It should be noted though that the grades obtained for both ninhydrin and DMAB are on the low end of the scale. Of the substrates tested, only the smooth wrapping paper resulted in more marks being identifiable after DMAB rather than ninhydrin treatment. This was also reflected in the mean and median grades for this substrate, where DMAB was rated higher than ninhydrin. In general, it was noted that there was an overall trend that samples which were given poor grades were less likely to give identifiable marks. Studies are currently underway to investigate the correlation between grading of developed marks with a scale versus a determination of whether they are suitable for identification by a fingerprint expert.

Substrate	DMAB			Ninhydrin		
	Identification Possible			Identification Possible		
	Yes	No	Mean Grade	Yes	No	Mean Grade
Colored Paper	6	4	1.6	10	0	2.3
Newspaper	2	8	0.6	3	7	0.7
Note Book Paper	4	6	1.5	8	2	1.6
Orange Envelope - Inside	0	10	0.6	7	3	1.5
Orange Envelope - Outside	1	9	0.2	6	4	1.4
Post-It Notes	0	10	0	6	4	2.4
White Envelope - Inside	0	10	1.1	4	6	1.3
White Envelope - Outside	2	8	1	7	3	1.6
Wrapping Paper - Inside	5	5	1.7	5	5	1.4
Wrapping Paper – Outside	6	4	1.5	5	5	1.2
Thermal Paper	3	7	0.9	7	3	1

Table 9

Absolute counts for identification results of DMAB-and ninhydrin-treated substrates and their corresponding mean grade from 10 exhibits per substrate.

Light Source Comparison

The illumination and recording of all DMAB-treated samples with both the Rofin Polilight PL500 and the much less expensive LED light sources (3W Cree Blue LED Mini Spot Light) presented the chance to compare these systems for a large number of DMAB-treated samples. It was generally noted that, although the LED was sufficient to detect ridge development in all samples that the Polilight could excite, the overall emission intensity was reduced, which impaired visualization with weaker deposits. All substrate investigation samples were graded using these two light sources, where the median grade for the Polilight was 1 and for the LED was 0 (mean grade of 1 and 0.6, respectively). This further reinforces the view that on difficult or weak impressions, the LED light source may not sufficiently excite the marks for identification purposes. Results of the blind study also suggest that the Polilight provides better excitation of developed samples, because all 75 deposited marks were observed. However, illumination using the LED light source still made possible the observation of 72 deposits. This indicates that, although the marks may be weaker, for nearly all of the deposits it was sufficient to demonstrate that a contact had occurred.

Because every fingermark reagent that can cause luminescence of treated fingermarks differs slightly with the required wavelength to achieve the appropriate excitation of the reaction product, the LED light source should be evaluated on a reagent-by-reagent basis. As expected, the overall excitation is lower than that of the Polilight illuminated samples. The inexpensive and more portable nature of the LED may still be of value, not only for smaller volume crime laboratories, but also for teaching and demonstration purposes. Although power is required from a 240 volt AC power outlet, its very low wattage (3 watts) makes this LED light amenable to simple power inverters that may be connected to a 12 volt DC car battery for remote field use.

Conclusion

In conclusion, DMAB can develop latent fingermark deposits on a range of different substrates. However, in the current form, the dry contact DMAB approach does not offer the same level of development as ninhydrin and cannot be recommended for routine operational use. Further investigations will be performed to compare this method with other dry contact methods, including 1,2-indanedione-zinc chloride [12] and *p*-dimethylaminocinnamaldehyde [9] and 1,8-diazafluoren-9-one [14].

An alternative excitation source in the form of an LED light was evaluated and compared to a Rofin Polilight, where the latter's more intense illumination provided better contrast. However, the much less expensive LED light source may be useful in teaching or remote environments where portability is an issue and the expense of the Polilight cannot be justified. The use of the LED light will be further investigated for the application with a range of different reagents, such as 1,2-indanedione-zinc chloride.

Lastly, the experiments were planned and conducted according to the IFRG guidelines. These guidelines were invaluable in addressing the issues associated with, and presenting the content expected from, a Phase 2 study appropriately.

Acknowledgment

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