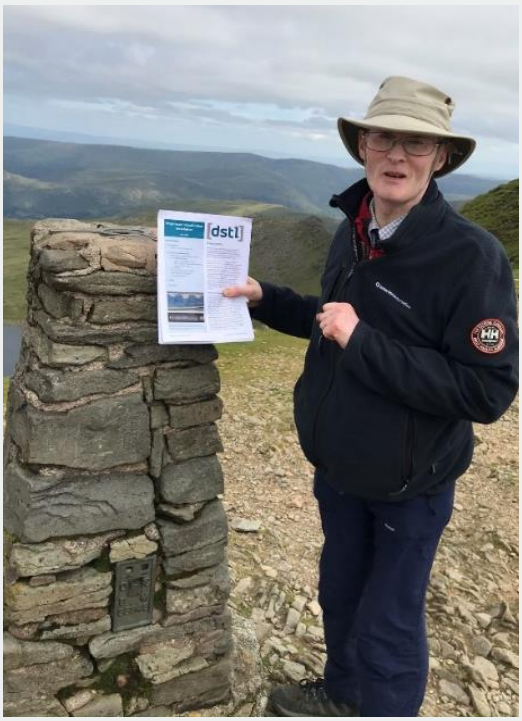
Fingermark Visualisation Newsletter

October 2020

The Science Inside

IN THIS ISSUE



The Fingermark Visualisation Newsletter reaches new heights as a copy of the last edition is taken to the top of Helvellyn in the Lake District by a keen member of our community!

INTRODUCTION

Everyone has been adjusting to a “new normal” due to the COVID-19 restrictions and the Forensics and Identity for Law Enforcement team at Dstl have been mainly working from home during this period. We have been planning updates for the next Fingermark Visualisation Manual (FVM) as well as drafting journal papers on RECOVER LFT and the reformulation of Physical Developer. All of the previous newsletters and the Source Book have been published on the Dstl government website and we will add future guidance documents to this page:

https://www.gov.uk/government/publications/dstl-forensic-publications

There has been fantastic participation in the Dstl collaboration exercise from UK fingerprint laboratories and bureaux. The exercise funded by the Home Office has been endorsed by the Forensic Science Regulator and the preliminary results are already showing the value in running a national evaluation of this type. International organisations are also taking part in the comparison exercise so we will be able to share and learn from good practice globally. A workshop was due to be held at the UK Fingerprint Enhancement Laboratory conference to discuss the findings but, as this has now been postponed, we will find an alternative way to share the results with you.

This newsletter provides guidance on recent chemical supply issues encountered by

Publication No. DSTL/PUB126361

laboratories as well as providing an update on the restrictions in place on some reagents. The newsletter also details the full processing instructions for the new Physical Developer formulation, which no longer contains Synperonic® N.

CHEMICAL SUPPLY ISSUES

The quality and availability of chemical supplies is vital to maintaining an effective fingermark visualisation capability. Over the years, many of the mainstream processes endorsed in the FVM charts have had to be modified due to restrictions in chemical supply. Some chemicals are subject to environmental legislative controls (such as Synperonic® N, HFE7100 and Triton™ X-100) whereas others have been discontinued due to commercial unsustainability (such as Kodak Photo-Flo and Fotospeed Blue Toner). This requires replacement reagents to be found and new formulations tested (ideally, before it becomes an issue) in order to maintain capability.

Dstl ensures that modified formulations undergo rigorous testing with the aim to establish at least comparable performance to the existing method if possible. This validation work enables the FVM to be updated with the latest guidance, including chemical specifications. The grade of chemical used in the validation study is also provided in the FVM and, where possible, the lowest suitable grade is specified. Higher purity chemicals can, unless stated otherwise, be used in all formulations, but they are typically more expensive and are unlikely to add value to mark recovery.

User caution is required when purchasing and receiving chemicals. This is especially important if suppliers are not the manufacturer of the chemical as their supplier could change without your knowledge and this may affect the quality of the chemical provided. Dstl has received a range of enquiries from police laboratories whereby an alternative grade of chemical has been supplied, or a reagent has been substituted for a similar chemical. These alternatives may not be equivalent to those used in the validation work, so careful monitoring of chemical supply is an important activity for any laboratory and, where appropriate, in-house testing may be required to ascertain effectiveness.

Some of the recent chemical quality and supply issues are explained in more detail in the next sections.

Basic Yellow 40 (BY40)

The name BY40 refers to several dyes with different CAS numbers and the one specified in the FVM is 29556-33-0. Alternatives are structurally similar and may be indistinguishable, in terms of mark enhancement, from the one given. However, there has been a report of cloudy ethanol-based BY40 solutions produced using an alternative CAS No: 35869-60-4. This product is the sulphate salt whereas the one specified in the FVM is the chloride. Although the fluorescent component of the molecule is the same, the alternative salt form may not dissolve completely causing cloudy solutions that should be avoided if possible.

Triton™ X-100

Triton™ X-100 is used in Powder Suspension and the water-based solutions used in Superglue Fluorescent Dye Staining. However, the supply could be discontinued from as early as January 2021 due to environmental concerns. We are in the process of validating a new powder suspension formulation using Tween® 20 but

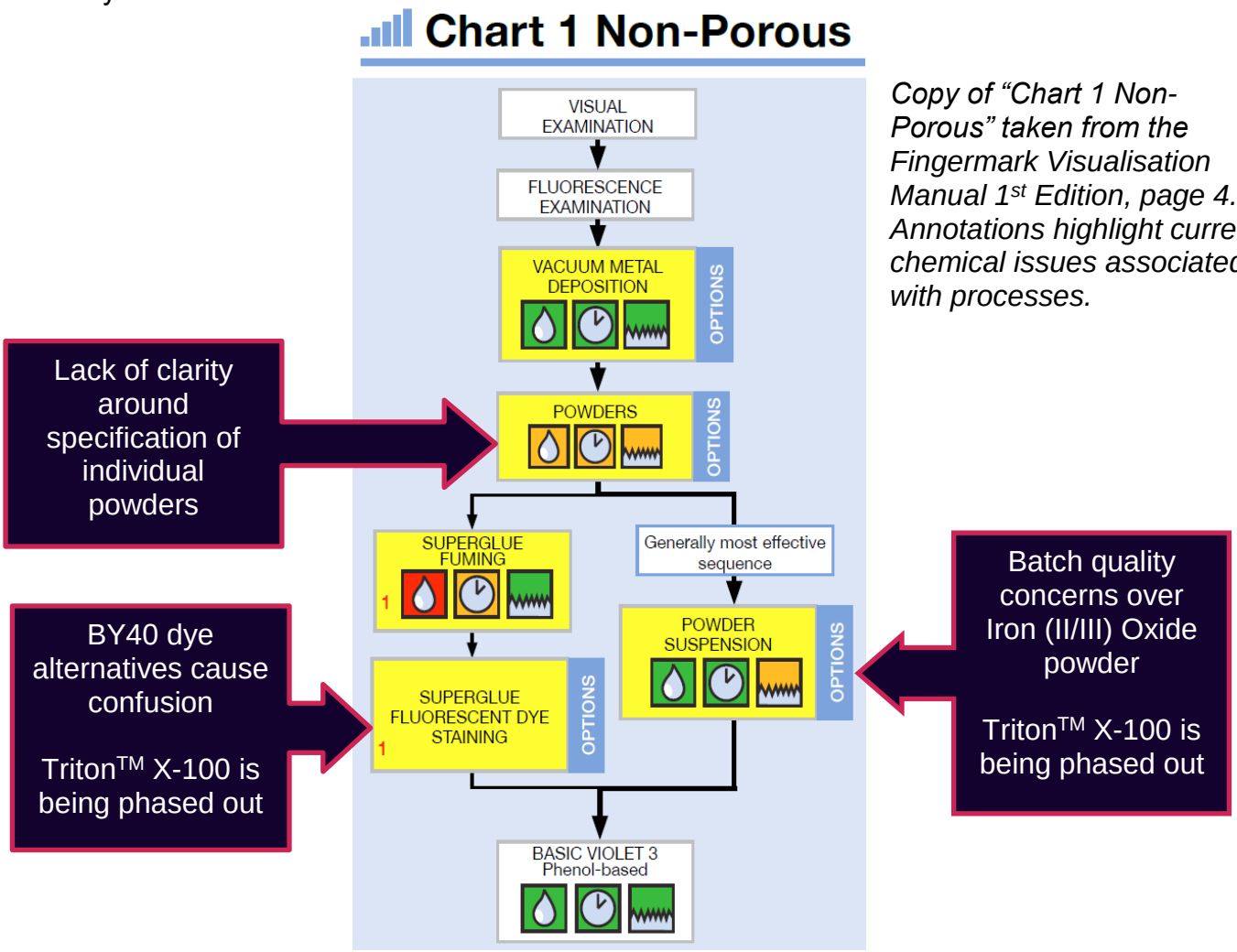
Publication No. DSTL/PUB126361

more research is required. **Laboratories may wish to ensure they have a plentiful supply of Triton™ X-100 to bridge the gap until alternatives can be fully validated.**

The CAS number for Triton™ X-100 in the FVM is 9002-93-1 as all validation studies have used this specification of detergent. An alternative CAS number for Triton™ X-100 is available (9036-19-5), but this product contains a mixture of isomers[1]. The FVM recommended product could be considered a tighter specification of the chemical, similar to a better quality grade, because it contains only one type of isomer. It is not known what impact this alternative product would have on fingermark development, so if you have been using an alternative in your laboratory then you would need to ensure its effectiveness is satisfactory.

Iron (II/III) oxide powder

In the course of our investigations to replace Triton™ X-100 in Powder Suspension, it was identified that the quality of the iron (II/III) oxide powder varied across batches. A more consistent and reliable iron oxide powder product has been found but further work is required to validate a new formulation. The new powder (Sigma Aldrich particle size 50-100 nm) has so far proven to be very effective in controlled experiments at Dstl when used in Tween® 20 detergent, but it is not effective when used in the current Triton™ X-100 formulation. Due to the current situation with regards to COVID-19 and relocating laboratories, Dstl have had to pause in-house laboratory work.



Copy of "Chart 1 Non-Porous" taken from the Fingermark Visualisation Manual 1st Edition, page 4.5. Annotations highlight current chemical issues associated with processes.

[1] *Molecules possessing the same composition and the same molecular weight, but differing in their chemical structure.*

Publication No. DSTL/PUB126361

Once our practical research is able to recommence, we will be working to reach a point where we are content with the level of validation for the new formulation. If your laboratory has noted a decline in performance or lack of success with the current FVM formulation, you may wish to conduct your own in-house studies to determine if switching to the new formulation will give a better outcome. See the March 2019 Newsletter on our website for further information and journal publication details.

Kodak Photo-Flo

The FVM states the stock detergent solution used in water-based Superglue Fluorescent Dye Staining solution and Powder Suspension can be replaced with Kodak Photo-Flo on a one-for-one basis. At the time that research was carried out on processes using Kodak Photo-Flo, little was known about different grades and so this was not included in the specification. It has come to our attention that different Kodak Photo-Flo products are available, so caution must be advised in order to select the correct product. Kodak Photo-Flo 600 with catalogue number 501 0640 is appropriate for this substitution as it contains Triton™ X-100 and ethylene glycol. Kodak Photo-Flo 200, for example, is more widely available to purchase, but it contains different ingredients and it has not been tested for this use.

Powders

Powders present their own unique problems. Unlike chemicals used in other process instructions, CAS numbers and grades are not given for the individual powders in the FVM and a description is given instead. This includes composition, particle size and morphology, and any surface coatings that are sometimes a consequence of the manufacturing process. These chemical *and* physical properties are critical to their success as a fingerprint powder.

Powders are typically purchased from forensic suppliers and, in many cases, it is difficult for end users to ascertain if a product bought today is the same as a product bought several years ago if the name is the same e.g., ‘aluminium powder’ or ‘black powder’. Equally, names can change even though the powder remains the same and this adds to the confusion, along with marketing words such as ‘special’ and ‘magic’. This brings into question the ongoing reliance on, and validity of, the original research behind the guidelines in the FVM which was conducted from 2002-2007, as it is unclear if the powders used now have changed significantly from those used in the original study. Major drops in performance of fingerprint powders in the field have not been reported to us since that study, which offers a level of reassurance. However, anecdotal information has been relayed in regards to issues with specific powders or lifting material by a small number of forces.

If relying on validation data behind the guidelines in the FVM, forces should ensure that the powders they buy meet the description as described in the FVM (5.Pow.9) and this information should be available from the supplier. If this information cannot be sought, or the powder falls outside of this description, then further validation work will be required to ensure they are fit-for-purpose.

Publication No. DSTL/PUB126361

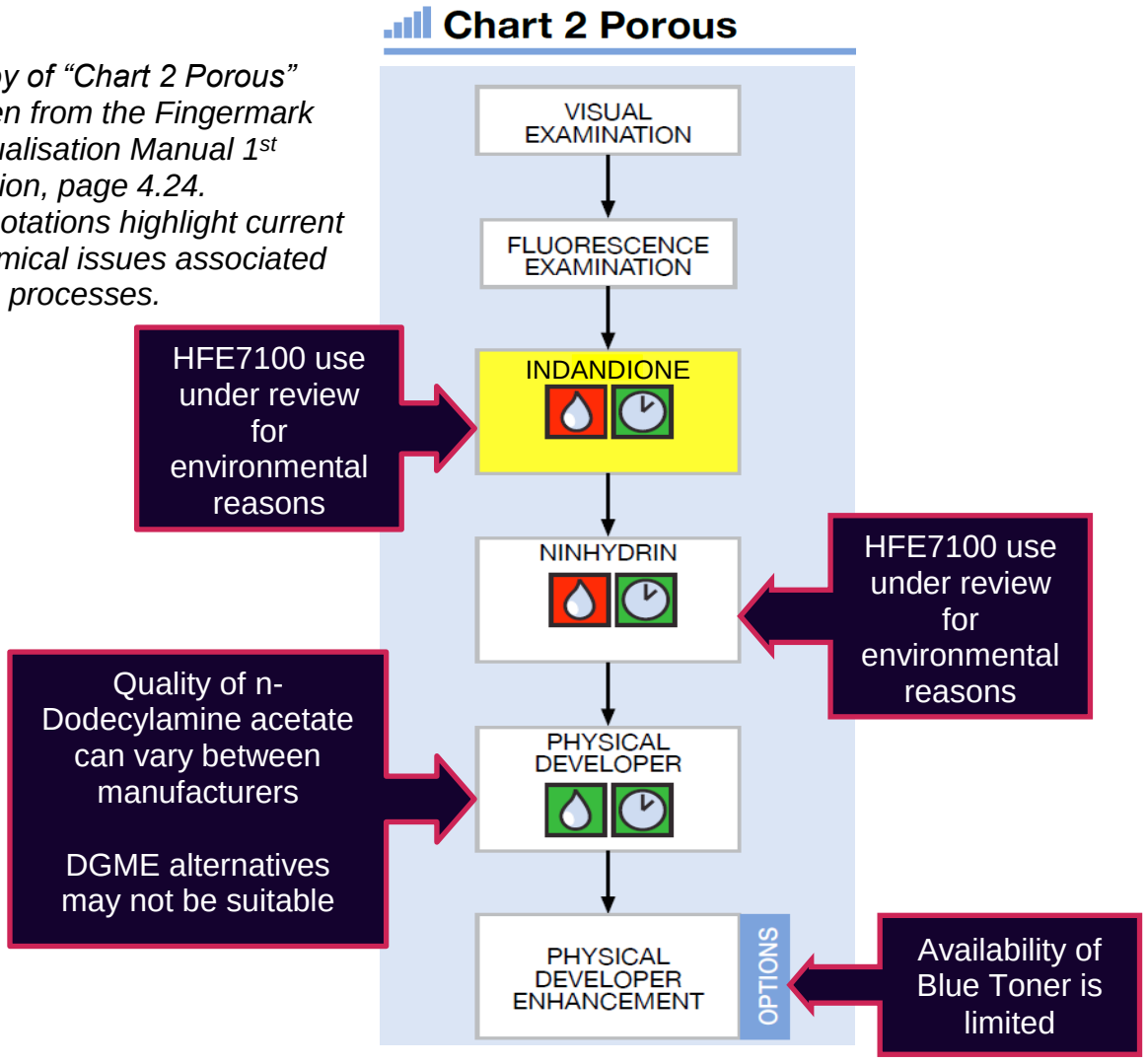
HFE7100

The carrier solvent HFE7100 used in Indandione and Ninhydrin is currently under review by the EU Regulation 517/2014. Further information on the potential restriction will be available by the end of 2022. Dstl is keeping a watching brief on this area, including possible future options, in the event that the availability of HFE7100 is limited in the future. See previous newsletters (February 2016 and March 2017) which can be accessed from our website for further information on fluorinated greenhouse gas reduction and its potential impact on fingermark visualisation.

n-Dodecylamine acetate

Physical Developer stock detergent contains n-Dodecylamine acetate and UK police laboratories now need to buy this from a chemical supplier, as it is no longer provided by Dstl. We recommend purchasing from Pfaltz & Bauer Inc. (Connecticut, USA) due to issues found with the quality of n-Dodecylamine acetate from other suppliers at the time of the study. Pfaltz & Bauer Inc. have UK distributors for n-Dodecylamine acetate, but we have not used this route so cannot comment on their service. If another chemical manufacturer is used then we would strongly advise testing is conducted to establish the chemical is fit-for-purpose. Cloudy stock detergent solutions were observed and impurities in the chemical were noted when sourced from alternative suppliers.

Copy of "Chart 2 Porous" taken from the Fingermark Visualisation Manual 1st Edition, page 4.24. Annotations highlight current chemical issues associated with processes.



Publication No. DSTL/PUB126361

Decaethylene glycol monododecyl ether (DGME)

The new Physical Developer formulation devised and validated by Dstl, with support from University of Leicester, contains the detergent DGME. An alternative chemical called Brij® 35 (also known as Brij® L23) has been supplied to a police laboratory as a substitute for DGME. Brij® 35 has the same CAS number and generic name "Polyethylene glycol dodecyl ether" as DGME. However, the two chemicals have differing molecular weights and structure so cannot be used interchangeably. The specific properties of both DGME and Brij® 35 are highlighted in the table below.

	DGME	**Brij® 35**
CAS No.	9002-92-0	9002-92-0
Molecular Weight	626.86	1198.0
Synonyms	Polyoxyethylene (10) lauryl ether	Polyoxyethylene (23) lauryl ether
No. of ethylene oxide groups	10	23
No. of alkyl groups	12	12

Blue Toner

Blue Toner is a useful Physical Developer Enhancement method; unfortunately, the commercial product has been discontinued by Fotospeed so its availability is limited. Dstl holds some stocks if required for UK forces and can provide details for alternative formulations that can be prepared in-house by laboratory staff. Although these formulations have not been tested against the commercial product, there is less risk with implementing them as Physical Developer Enhancement is at the end of the sequence.

In addition, iodide toning and sulphide toning are still available alternative options to improve the contrast of Physical Developer marks. Please contact us if you would like further information on the alternative formulations of Blue Toner available.

Summary

Listed below are a few key points to note when ordering chemicals and ensuring they are suitable for use:

- A product with the same CAS number does not always mean it is exactly the same chemical. Use other information available within the specification (such as alternative names, grade, physical properties etc.), in addition to the CAS number, to ensure you purchase the correct product.
- Products can vary in quality from batch-to-batch. Visual checks, monitoring mark visualisation performance and the use of control/test piece samples may help identify this issue.
- Occasionally, a supplier may alter the composition of a commercial product so pay close attention to any visual changes (such as colour) and check supporting documentation (such as the Safety Data Sheet, Certificate of Analysis etc.) to determine the ingredients used.
- Quality can vary between manufacturers so check chemical grades, inspect reagents on arrival and look for any unusual properties (e.g. cloudiness) when preparing solutions in-house.

Publication No. DSTL/PUB126361

For further guidance on what to look for when checking chemicals are suitable for use, see FVM (Section 3.3: Working Effectively).

PHYSICAL DEVELOPER PROCESS INSTRUCTION CHANGES

The new Physical Developer formulation was released in our November 2019 newsletter. This formulation has been developed in order to replace Synperonic® N, which was banned due to environmental legislation. The validation work on this new formulation has been drafted for journal publication and we hope that it will be available for download in the coming months.

For any police forces wishing to add these publications to their validation libraries, the appropriate references are:

- A. Thomas-Wilson, Z. Guo, R. Luck, L. J. Hussey, M. Harmsworth, J. L. Coulston, A. R. Hillman, V. G. Sears, *Replacing Synperonic® N in the Physical Developer Fingermark Visualisation Process: Reformulation* – manuscript in preparation
- E. M. Cartledge, Z. Guo, S. M. Bleay, V. G. Sears, L. J. Hussey, *Replacing Synperonic® N in the Physical Developer Fingermark Visualisation Process: Pseudo-Operational Trial and Parameter Studies* – manuscript in preparation

The formulation now incorporates Decaethylene glycol monododecyl ether (DGME) instead of Synperonic® N, and differing quantities of detergents are necessary to prepare the stock solution. The volume of stock detergent required has also changed so the formulation now produces a 1L working solution.

The new formulation was tested on a wide range of surfaces in the pseudo-operational trial, but it was not possible to test every substrate type. For example, the formulation has not been tested on arson items but we have no reason to expect it not to work. Wetted items and previously treated items were however included in the validation work, along with commonly encountered porous items such as newspapers, envelopes and cardboard.

Physical Developer fingermark visualised with the DGME-based formulation during the pseudo-operational study.

The health and safety risks associated with the Physical Developer working and stock detergent solutions have not yet been re-assessed to incorporate reformulation, and therefore “Health and Safety: Labelling Solutions” is excluded from the processing instructions. This information will be published in the next FVM update. In the interim, please use the Safety Data Sheets associated with the detergents to perform an in-house assessment of the risks.

Publication No. DSTL/PUB126361

DGME is in the form of a semi-solid and is often received in a bottle with a narrow neck.

The reagent can be heated gently in order to transfer it to a container with a larger opening. The other detergent in the stock solution (n-Dodecylamine acetate) is not commonly available so we have recommended a reliable supplier (Pfaltz & Bauer Inc.) as mentioned in the Chemical Supply Issues article.

DGME in the form of a semi-solid that has been decanted into an appropriate container.

Our studies have shown that the working solution is stable and that the processing time is not an issue at lower temperatures (tested down to 15°C). We have therefore removed the requirement that solutions must be kept above 17°C, however, it is still good practice to operate at room temperature.

It was recognised that the silver deposition time is slightly quicker than for the old formulation, and the shelf-life of the working solution is shorter. It should be used on the day of preparation as the effectiveness drops off over time. The guideline expiry date of the new stock detergent is still 12 months.

A very slight decrease in the effectiveness of the redox solution over a 6-month period was identified by our research. Therefore, a 6-month guideline expiry for the redox solution is recommended with checks to ensure the effectiveness is maintained.

It is likely that the redox solution becomes oxidised over time so storage in a sealed container with a minimal air-gap at the top of the bottle will maximise the shelf-life.

Photograph of the underneath of a bottle of a DGME-based Physical Developer working solution - on the day of preparation showing clear solution (top), aged for 48 hours exhibiting some silver deposition (bottom).

These changes are incorporated into the Physical Developer Process Instructions outlined below, and are highlighted in yellow.

Publication No. DSTL/PUB126361

A PHYSICAL DEVELOPER

Alternative Names

PD

Contents

Main Uses

✓	Latent	✗	Non-Porous
✗	Blood	✓	Semi-Porous
✗	Grease	✓	Porous

Key Information

- **Competent personnel** specialising in fingermark visualisation must be consulted if considering the use of this process.
- It is recommended that all sections are read prior to using this process for the first time.
- Full process details are given for **laboratory use** only.

Process Overview

Physical Developer works by preferentially depositing silver metal onto fingermark ridges resulting in grey/silver-coloured fingermarks. It is believed to detect the presence of sebaceous trapped eccrine constituents which assist deposition of silver during development of the fingermark. It is a chemical process that involves exposing the item or surface to three solutions in sequence.

Safety and Effectiveness Summary

The Process

- Physical Developer can be used safely and effectively when used in a laboratory. At scenes, the application is generally considered impractical.
- The effectiveness depends on close observation of fingermark and background development and the condition of the processing solutions.
- Developed fingermarks may be faint or obscured by the surface colour or pattern; use of subsequent **Physical Developer Enhancement** or **IR Reflection** may improve contrast.

The Item or Surface

- The process is most effective at developing latent fingermarks on porous and semi-porous surfaces.
- It can be used on surfaces that are wet, or have been wetted and subsequently dried.
- It can be used on surfaces that have been subjected to moderate levels of heat.

Integrated Use

Physical Developer may be detrimental to subsequent fingermark or forensic processing.

- See Chapter 4: Process Selection for information on its sequential use with other fingermark visualisation processes.
- See Chapter 7: Other Forensics for information on integration of fingermark and other forensic processes.

Publication No. DSTL/PUB126361

Laboratory or Scene?

This page only gives an **overview** of **health and safety, effectiveness** and **practical issues** associated with the use of this process. Those responsible for deciding whether to process items in the laboratory or at the scene, e.g. crime scene managers or investigators, must consider in addition to the information below:

- the detailed process instructions; and
- other factors dictated by the investigation.

See **Chapter 2, Section 2.4,** 'Fingermark Evidence Recovery Planning'.

Physical Developer can be used safely and effectively in the laboratory, but is normally considered impractical to use at scenes.

Health and Safety

Physical Developer can be used safely in the laboratory and at the scene.

Effectiveness

The process is at its most effective when used in the laboratory environment, where items can be immersed in Physical Developer. For use at scenes, consideration of the ability to immerse the surface for a sufficient period of time must be considered.

Practicality

Physical Developer is at its most effective when the processing is carried out in a dish. In a laboratory, the process has few practicality issues. At the scene, achieving the sequence of chemical conditions required for use of Physical Developer is extremely difficult and usually considered impractical.

Publication No. DSTL/PUB126361

Health and Safety

- Consult Chapter 3 for **general** information on **working safely** with Category A processes.
- Physical Developer may be carried out with no known hazards to health provided practitioners are trained and competent, if appropriate control measures are in place and the process is carried out as described in this Manual.
- Throughout the process instruction there may be reference to chemical hazards (e.g. *'residual processing chemicals on items are hazardous'*) and/or control measures (e.g. *'work within a fume cupboard'*). These are based on the authors' local risk assessment (and Safety Data Sheets) and must not be assumed to be appropriate in all situations, but are given as guidance only.

General Health and Safety Information

- The health and safety information provided throughout the Manual must be considered as guidance only: definitive health and safety policies, procedures and instructions must be provided locally.
- In providing the Category A process instructions it is assumed that:
  - the process will be carried out in a laboratory that can provide a safe working environment;
  - a responsible person will carry out a risk assessment before the process is carried out to include at least:
    - an assessment of the practitioner's competence to carry out the process;
    - a review of all the hazards associated with the use of the process, consulting relevant documents, such as Safety Data Sheets (SDSs), where necessary;
    - a review of all the hazards associated with the working environment, the item(s) and any contaminants present.
- All control measures identified will be put in place, including the wearing of appropriate PPE, and reviewed for their effectiveness.
- Where information is included for scene use of the processes, the considerations are over and above those for laboratory applications of the processes.

Hazards associated with Physical Developer

- Physical Developer is a **chemical** process.
- Practitioners will need to know the hazards associated with handling individual chemicals (from SDS) and the hazards associated with the process solutions.
- Wear Standard PPE as a minimum.
- There are no additional hazards associated with the process.

Publication No. DSTL/PUB126361

Equipment

Physical Developer requires the use of some process-specific equipment for the preparation and application of the solutions. **General laboratory equipment** that may be required is outlined in Chapter 3.

Equipment	Requirements
Glassware for solutions containing silver nitrate	Glassware for solutions containing silver nitrate **must**: ▪ be thoroughly clean; ▪ be scratch free.
Processing dishes for Physical Developer Working Solution and Maleic Acid Solution	The processing dish **must**: ▪ be non-metallic; ▪ **be scratch free** (for Physical Developer Working Solution only); ▪ be large enough to process the item without folding. *Use-once disposable plastic liners may be considered to line damaged processing dishes.*
Implement to move items during processing, such as forceps, tongs or fish slice	The implement **must**: ▪ be smooth and non-metallic; ▪ not have serrated or sharp edges or have ridges.
Equipment that will deliver an indirect source of fresh running water, such as a print-washer	The equipment **should**: ▪ be capable of being attached to a regulated flow of water, such as a tap; ▪ be designed so that items stay within the confines of the equipment and not damaged by water flow.

Publication No. DSTL/PUB126361

Chemicals

This table lists chemicals that are required for Physical Developer.

Refer to supplier's Safety Data Sheet (SDS) for further information on specified chemicals. Unless specified, water used within the solutions or for rinsing is purified.

See **Chapter 3 safe handling of chemicals** for general information.

Common Name	Alternative Name(s)	CAS Number	Grade
Ammonium iron (II) sulphate hexahydrate	Ferrous ammonium sulphate; Ammonium iron sulphate	7783-85-9	Analytical
Citric acid anhydrous	2-hydroxypropane-1,2,3 tricarboxylic acid	77-92-9	Analytical
n-Dodecylamine acetate	Aminododecane acetate; Laurylamine acetate	2016-56-0	As supplied, see note*
Iron (III) nitrate nonahydrate	Ferric nitrate nonahydrate; iron nitrate; ferric nitrate	7782-61-8	Analytical
Maleic acid	cis-butenedioic acid; toxilic acid	110-16-7	Laboratory
Silver nitrate	Silver (I) nitrate	7761-88-8	Laboratory
Decaethylene glycol monododecyl ether (DGME)	Polyoxyethylene (10) lauryl ether	9002-92-0	Laboratory

**The quality of n-Dodecylamine acetate varies considerably between manufacturers. Pfaltz & Bauer Inc. supplied the only reliable product that Dstl was able to locate worldwide (at the time the work was undertaken); although other suppliers are available, appropriate testing must be carried out to ensure that the product is fit-for-purpose.*

Publication No. DSTL/PUB126361

Solutions

Consult Chapter 3 for general information on **solution preparation, safe storage of chemicals, solutions and mixtures** (which includes information on **packaging and labelling**), **management of waste for disposal** of solutions and **guideline expiry periods**. This page gives additional information relevant to this process.

Solutions

Maleic Acid Solution
25 g Maleic acid
1 L Water

Physical Developer Working Solution
900 mL Physical Developer Redox Solution
50 mL Physical Developer Stock Detergent Solution
50 mL Silver Nitrate Solution

Physical Developer Redox Solution
30 g Iron (III) nitrate nonahydrate
80 g Ammonium iron (II) sulphate hexahydrate
20 g Citric acid anhydrous
900 mL Water

Physical Developer Stock Detergent Solution
1.25 g Decaethylene glycol monododecyl ether
1.5 g n-Dodecylamine acetate
1 L Water

Silver Nitrate Solution
10 g Silver nitrate
50 mL Water

Final solutions are identified by a red border

Publication No. DSTL/PUB126361

Solutions continued …

(1) Prepare solutions →

a) DGME is in the form of a semi-solid and is often received in a bottle with a narrow neck. The reagent can be heated gently in order to transfer it to a container with a larger opening.
b) All solutions must be **thoroughly mixed** and one chemical should be added at a time and allowed to dissolve to reduce the risk of cloudy solutions. Physical Developer Stock Detergent Solution may require stirring for several hours.
c) Water and solutions used within Physical Developer Redox and Working Solution should be at room temperature prior to mixing.
d) See **Physical Developer Equipment** for glassware requirements for solutions containing silver nitrate. In addition, all labware must be **scrupulously clean** and **dust free**.
e) Silver Nitrate Solution should be added last to the working solution.
f) Maleic Acid, Physical Developer Stock Detergent and Silver Nitrate Solutions are colourless.
g) Physical Developer Redox and Physical Developer Working Solutions may vary in appearance from a yellow/brown to a brown/green colour.

(2) Label appropriately →

a) All solutions should be labelled in line with the guidance in **Physical Developer Health and Safety**[2].

(3) Store appropriately →

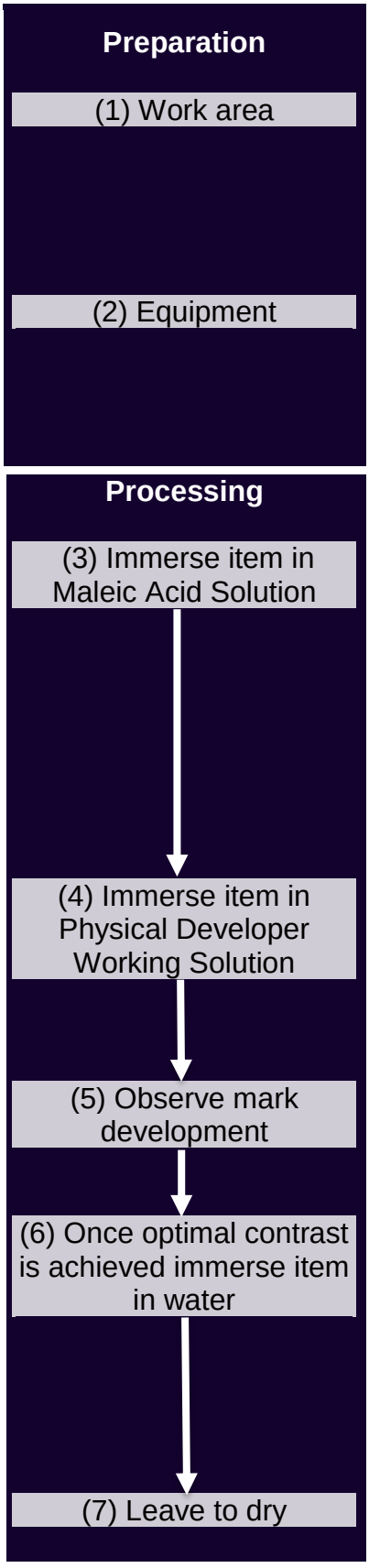
a) Maleic Acid Solution and Physical Developer Stock Detergent Solution have guideline expiry dates of 12 months.
b) Physical Developer Redox Solution has a guideline expiry date of 6 months after preparation if stored at room temperature.
c) Physical Developer Working Solution and Silver Nitrate Solution should be made and used on the day of preparation as the effectiveness decreases over time. If there is a short time delay between preparation and use, the solution must be stored in the dark**.** It must be stored in a vessel that is clean and scratch free. A small amount of white sediment may appear but this does not affect performance. If sediment is silver/grey, do not use.

(4) Dispose of appropriately

[2]This information is to be determined and will appear in FVM 2nd Edition. Use Physical Developer Health and Safety labelling solutions page from the FVM 1st Edition as guidelines.

Publication No. DSTL/PUB126361

Processing



a) The **work area should not be in direct sunlight**.
b) There should be sufficient space available to accommodate all dishes and the print-washer or equivalent (if used). This is typically 4-6 vessels.

a) Pour Maleic Acid Solution into one dish; Physical Developer Working Solution into another dish; water into the remaining dishes. Add sufficient solution to immerse the item. Attach the **print-washer**, or equivalent, to a tap for the final continuous wash. *In addition to the* **equipment** *requirements for the dishes used for Physical Developer Working Solution, the internal surfaces must be* **scrupulously clean** *and* **dust free** *before use.*

a) Immerse the item for ten minutes or until **bubble evolution** from the item ceases, whichever is the longer. Occasionally agitate the dish.
b) This step can be omitted for wood and **fragile papers** such as tissue or charred paper.
c) Multiple items may be treated in the same dish throughout processing, although they must **not overlap** or **be folded**.
d) **Physical contact with the item should be kept to a minimum** throughout processing.
e) Replenish the solution as necessary. Discard if the solution becomes exhausted or badly contaminated with debris.

a) Immerse the item and occasionally **agitate the dish**.
b) Replace the solution as necessary. Discard if the solution becomes badly contaminated with debris or if dark grey/silver particles are observed at the bottom of the dish or **floating on the surface** of the Physical Developer Working Solution.

a) Grey-coloured marks will be developed which gradually darken with development.
b) Optimal contrast is normally achieved within 15-25 minutes.
c) **As more items are treated the development time increases**. Eventually the development time will become unacceptable and the solution must be discarded, the dish can be rinsed with water and refilled.

a) Immerse the item in water wash dishes, each for about five minutes with occasional agitation, until all Physical Developer Working Solution has been removed. Change the wash water when it appears yellow.
b) Finally, **wash for at least ten minutes** in a print-washer or equivalent.

a) See **Drying of items** in chapter 3 section 3.3**.**

Publication No. DSTL/PUB126361

Processing continued…

(8) Examination

Primary: **Visual Examination**

Secondary: **Fluorescence Examination; IR Reflection**

→

a) Visible marks are grey/silver in colour when the item has dried.
b) Weak marks may only be seen when the paper is completely dry.
c) If washing has not been thorough, the background can discolour so it is important to image all fingermarks found immediately.
d) There are many non-destructive optical processes that can be considered when examining and imaging marks in addition to Visual Examination, Fluorescence Examination and IR Reflection, particularly for low-contrast marks or marks on dark or patterned surfaces.
e) Mark up viable fingermarks appropriately and capture image.
f) After examination, items with light-coloured marks and little background development can be re-treated if necessary but immersion in maleic acid is not required.

Publication No. DSTL/PUB126361

Post-Processing

Consult Chapter 3 for **general** advice on **packaging**, **storage**, **disposal or return of items**, and **management of waste for disposal** of equipment, chemicals, solutions and mixtures. This page gives additional information relevant to this process.

Processed item		
(1) Cleaning processed items	→	a) It is not possible to return items to their original state.
(2) Disposal or return of processed items	→	a) Residual processing chemicals that are present are non-hazardous so items can be discarded with ordinary waste or returned to the owner.

Equipment and Chemicals		
(3) Disposal of used Physical Developer Working Solution	→	a) Physical Developer Working Solution should not be re-used.
(4) Cleaning of processing dishes	→	a) Processing dishes must be thoroughly washed and dried with a soft cloth or tissue. Stubborn stains may be removed with a neutral detergent, **never abrasive cleaning products**, and then dishes must be thoroughly rinsed to remove any remaining detergent before drying.
(5) Cleaning of laboratory surfaces	→	a) It is not normally possible to remove silver stains from laboratory coats, balances, benching, flooring etc. so care should be taken when handling solutions containing silver.

Publication No. DSTL/PUB126361

Grey Deposition on Labware

Recognition

A grey deposit has appeared on labware that has come in contact with the Physical Developer Working Solution.

Silver from the Physical Developer Working Solution depositing on the sides and bottom of the dish.

Cause	Effect	Prevention	Correction
Imperfections on the surface of processing equipment causes silver deposition from solution.	The working solution becomes depleted of silver ions. This may result in slow and/or weak development of marks.	Ensure that labware used for processing is scrupulously clean and free of scratches. Use-once disposable plastic liners may be considered to line damaged dishes.	Items with weak or apparently no development can be re-treated using fresh Physical Developer Working Solution.

Publication No. DSTL/PUB126361

Cloudy Working Solution

Recognition

The Physical Developer Working Solution is cloudy in appearance.

Physical Developer Working Solution of correct appearance.

'Cloudy' Physical Developer Working Solution.

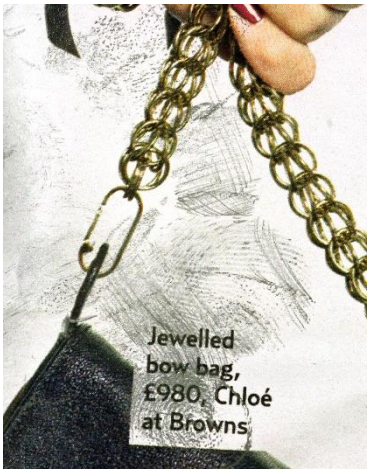
Cause	Effect	Prevention	Correction
Some components within the solution have not dissolved or have precipitated out from solution causing loss of clarity and change in colour of the Physical Developer Working Solution.	The working solution does not have the fine chemical balance required for optimum mark development. This may result in: ▪ marks not being developed; ▪ marks only being developed very faintly and being missed during examination.	Ensure that: ▪ the purity of chemicals and water are the recommended grades; ▪ the temperature of all of the solutions should be at room temperature prior to and during mixing as well as during processing; ▪ the solution is thoroughly mixed between the addition of each reagent and solution when making Physical Developer Working Solution; ▪ processing is carried out away from direct sunlight to avoid photo-degradation.	There are no corrective measures.

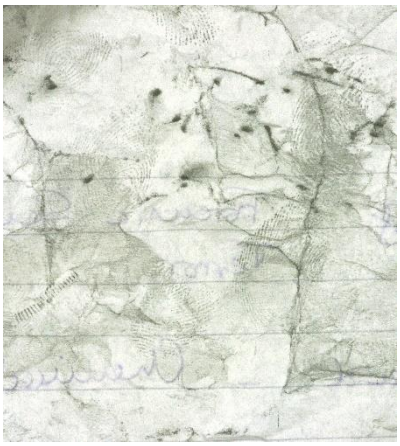
Publication No. DSTL/PUB126361

Localised Areas of High Background Development

Recognition

There are localised areas of high background development, sometimes appearing within folds or areas that have been abraded or handled.





Porous items treated with Physical Developer showing silver deposition on marks and (left) scrapes caused by incorrect handling and (right) creases and abrasions.

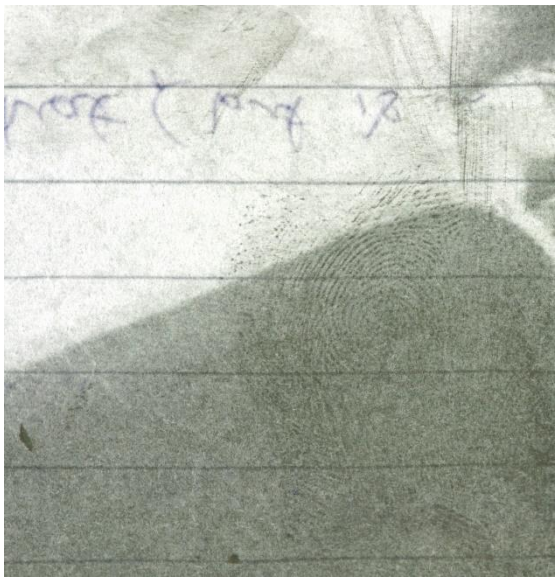
Cause	Effect	Prevention	Correction
Imperfections on the surface of the item cause preferential silver deposition from solution onto these areas.	Marks may be obscured or obliterated.	Ensure that items are handled carefully, avoiding creasing, and minimising any abrasion of the surface with gloves. Smooth tongs and fish slices may be used where handling is required.	There are no corrective measures.

Publication No. DSTL/PUB126361

Uniform High Background Development

Recognition

The porous item appears uniformly grey either across the whole area or in uniform patches.



White writing paper processed with Physical Developer showing high background development.

Cause	Effect	Prevention	Correction
Filler particles in the substrate have not fully reacted in the maleic acid pre-wash, and react directly with the Physical Developer Working Solution. This reaction acts as nucleation sites for silver deposition.	High background development occurs across the whole surface, giving a dark grey background, which may obscure developed marks.	Ensure that: ▪ the item remains in the maleic acid pre-treatment until bubbles are no longer emitted from the surface; ▪ items don't overlap during treatment; ▪ air is not trapped between the item and the solution.	There are no corrective measures.
The substrate and working solution have been exposed to excessive light/sunlight during processing.	High background development occurs across the whole surface, giving a dark grey background, which may obscure developed marks.	Ensure that: ▪ the item remains fully immersed in the working solution during processing; ▪ the processing area is protected from direct sunlight; ▪ items don't overlap during treatment.	There are no corrective measures.

Publication No. DSTL/PUB126361

Substrate Damage from Maleic Acid Solution

Recognition

The porous item breaks up or blisters when immersed in Maleic Acid Solution.

Paper substrates have been detrimentally affected by the maleic acid pre-wash, including signs of (left) physical degradation and (right) blistering of the surface.

Cause	Effect	Prevention	Correction
Heavily recycled papers (and some other substrates) may contain short fibres and high quantities of filler used for binding. The binding between the short fibres is easily disrupted during the reaction of the filler with maleic acid.	The substrate becomes fragile and/or breaks up while immersed in solution, destroying any marks that may be present.	Consider omitting the maleic acid pre-wash stage (especially for fragile materials such as tissue paper). If the issue cannot be overcome by omitting the pre-wash, consider alternative processes for this substrate.	There are no corrective measures.
Surface coatings or calendared layers present on some papers can inhibit the release of bubbles formed when the item is immersed in maleic acid.	Localised ‘blisters’ form within the substrate which may act as preferential nucleation sites for silver. Both preferential silver deposition and the blisters themselves may obscure or obliterate marks.	Consider omitting the maleic acid pre-wash stage. If the issue cannot be overcome by omitting the pre-wash, consider alternative processes for this substrate.	There are no corrective measures.

Publication No. DSTL/PUB126361

Under-Developed Mark

Recognition

After processing with Physical Developer the developed mark is very faint.

Paper packaging processed with Physical Developer showing weakly developed marks.

Cause	Effect	Prevention	Correction*
The item has not been exposed to the Physical Developer Working Solution for long enough to allow adequate development.	Lower than optimum amounts of silver are deposited on the mark. Developed marks are faint and difficult to detect, weaker marks may not be developed.	Ensure that items are exposed to the working solution for a sufficient period of time (~15-25 minutes for fresh solution, longer for older solutions).	Re-treat with Physical Developer.
The Physical Developer Working Solution has become exhausted and insufficient silver is present to fully develop marks.	Lower than optimum amounts of silver are deposited on the mark. Developed marks are faint and difficult to detect, weaker marks may not be developed.	Continuously monitor for signs of solution depletion such as deposition of silver in the processing dish. Use test spots if available.	Replace used solution with a fresh batch and re-treat item.
The item has been left without occasional agitation of the Physical Developer Working Solution, resulting in local depletion of silver ions.	Lower than optimum amounts of silver are deposited on the mark. Developed marks are faint and difficult to detect, weaker marks may not be developed.	Ensure that the solution is gently agitated at regular intervals to maintain a uniform distribution of chemicals within the solution.	Replace used solution with a fresh batch and re-treat item.
The mark contains limited constituents suitable for visualisation with Physical Developer.	Developed marks are faint and difficult to detect.	There are no preventative measures.	There are no corrective measures.

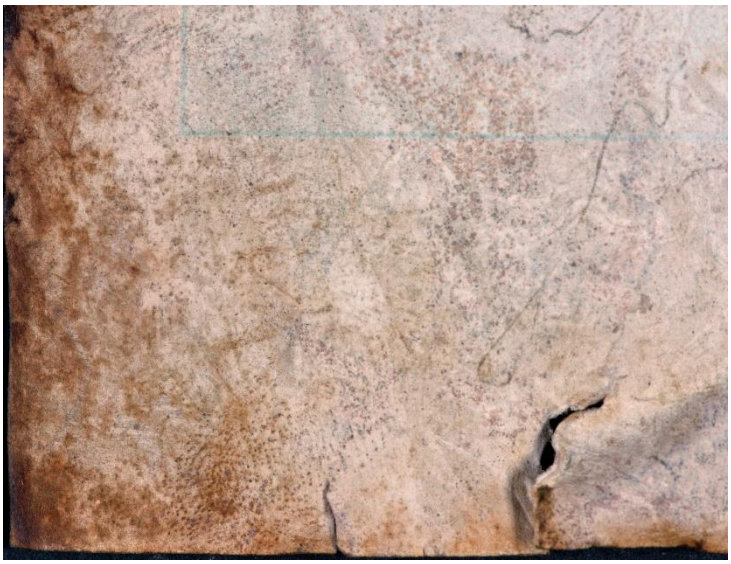
* *Any weak marks can be processed with* **Physical Developer Enhancement** *or viewed using* **IR Reflection**

Publication No. DSTL/PUB126361

Colour Change to the Substrate Post-Processing

Recognition

The processed porous item appears ‘rusty’ in areas. This colour change has occurred over time.



White photocopier paper treated with Physical Developer with areas of strong discolouration after one month.

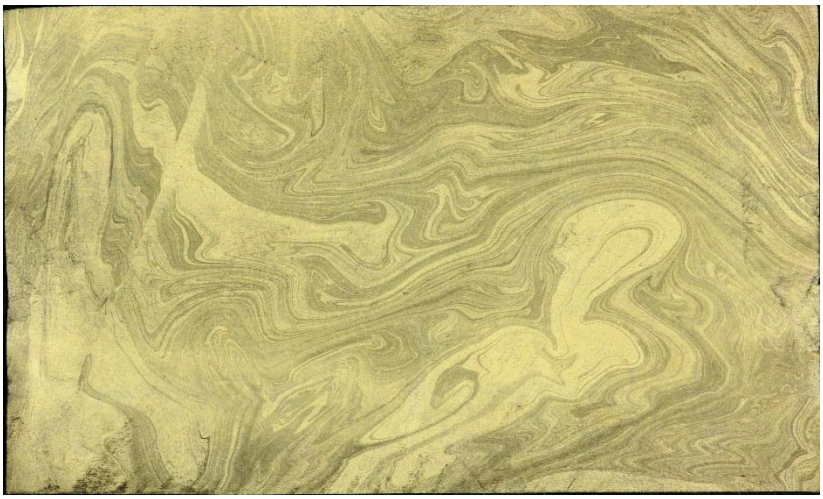
Cause	Effect	Prevention	Correction
Incomplete washing of the item during the final stages of processing has resulted in iron salts and other trace chemicals still being present in the substrate after processing.	Subsequent oxidation reaction of the residual iron salts over time results in localised areas of discolouration. These may progressively obscure or obliterate developed marks.	Ensure that the item is washed for a sufficiently long period after processing and immediately photograph any useful marks.	There are no corrective measures.

Publication No. DSTL/PUB126361

A Swirly Pattern is Deposited on the Item

Recognition

The item develops a ‘marbling’ pattern during processing.



A yellow post-it-note paper treated with Physical Developer where silver has deposited in a swirly pattern, also known as ‘marbling’.

Cause	Effect	Prevention	Correction
The ‘marbling’ effect is caused by either: • the presence of dust left on the internal surfaces of the dish used for Physical Developer Working Solution; • or dust from the laboratory settling onto the surface of the Physical Developer Working Solution during processing.	Any dust in the Physical Developer Working Solution or on the surface can adhere to the surface of the item being treated. These dust particles disrupt the silver micelles and act as seeds for silver deposition. The result can be seen as a swirly pattern or ‘marbling’.	Ensure that the dish used for Physical Developer Working Solution is scrupulously clean and dust free and that the laboratory is free from floating dust.	There are no corrective measures.

Publication No. DSTL/PUB126361

Theory

The Physical Developer process works by preferentially depositing silver metal onto fingermark ridges. Development relies on a balanced electrochemical reaction, which can be affected by ions present from contamination, temperature, surface defects on labware and on the item being treated. Therefore, for successful implementation of this process, it is important to use chemicals of the correct grade, scratch-free labware and to ensure minimal handling of items prior to treatment.

The Physical Developer Solution is a modified photographic developer that contains silver ions, a ferrous/ferric oxidation/reduction system that acts as a reducing agent for the silver ions, and a citric acid buffer. The reversible reaction below is set up:

$$Ag^{+} + Fe^{2+} \leftrightarrow Ag + Fe^{3+}$$

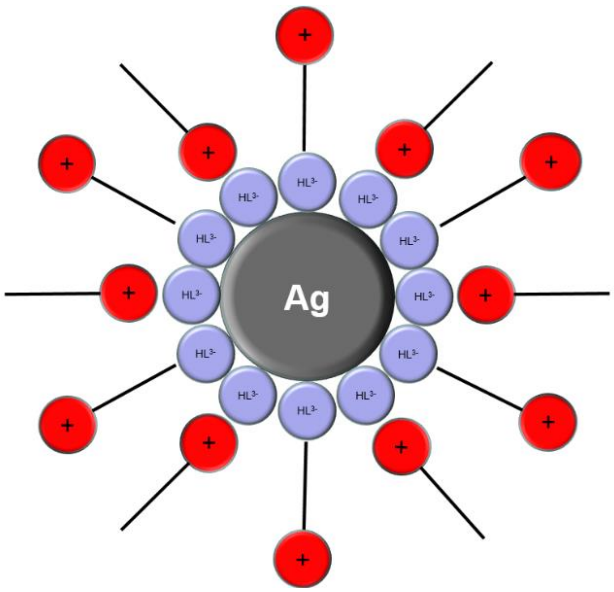
The formulation is stabilised by the inclusion of a cationic surfactant, which acts to surround the particles of silver as they are formed by enveloping them in a positively charged shell (known as a micelle).

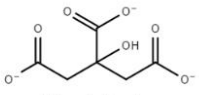
These micelles repel the positively charged silver ions thereby preventing growth of the silver particles when in solution.

The relative concentrations of each component are in balance so that the Physical Developer Working Solution remains fairly stable until items to be treated for fingermarks are introduced into the solution. The silver micelles are then disrupted by fingermark components, some other contaminants or damage to the surface of the item and the tiny silver particle is deposited onto the surface.

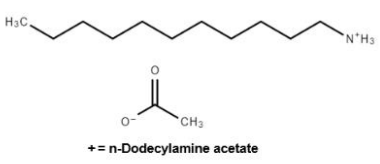
It is unknown what it is within the fingerprint that causes the disruption to the silver micelles or its mechanism, but studies have shown that there are probably water-soluble components that are trapped within a water-insoluble emulsion of sebaceous material.

Once a particle of silver has been deposited on the surface it acts as a seed growing by interaction with silver ions. Where there is a large amount of contamination, for example along fingermark ridges, many silver particles are deposited and as they grow they will become visible as grey-/silver-coloured marks.





Schematic diagram showing the formation of micelles around a silver particle.



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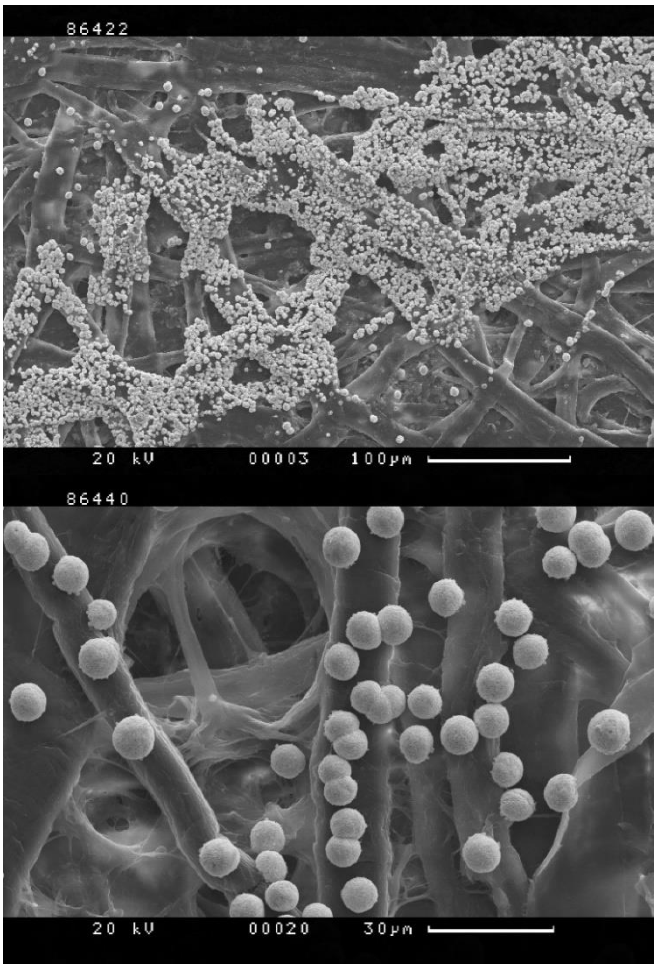

Scanning electron micrographs of silver particles deposited on fingermark ridges on a paper substrate.

Some of the Physical Developer chemicals, in particular the ammonium iron (II) sulphate hexahydrate, cause an endothermic reaction, which reduces the temperature of the solution. This can result in incomplete dissolution of the chemical, which can lead to cloudy solutions and premature silver deposition. It is therefore recommended that when preparing the redox solution, the starting temperature of the water should be approximately 20°C and that one chemical should be added at a time and allowed to dissolve. This will reduce the risk of cloudy solutions and allow for issues with individual chemicals to be identified if present.

Purified water is recommended for the preparation of Physical Developer solutions. It is known that some impurities found in water will cause the silver to precipitate prematurely from the solution. If low quality water is causing issues with the performance of Physical Developer, then it is recommended to upgrade the water purification method in use in the laboratory. The validation work carried out by the author utilised grade 2 reverse osmosis deionised water and no issues were encountered with solutions incorporating this grade of water.

When treating porous items for fingermarks with Physical Developer, some papers have alkaline binders and fillers that react directly with the acidic Physical Developer Working Solution. This reaction destabilises the silver micelles and silver is rapidly deposited at the reaction sites and unable to develop fingermarks. Therefore, included in the process is a maleic acid pre-wash for papers that require it, where the maleic acid reacts with the alkaline binders and fillers to neutralise them, forming an insoluble salt and generally carbon dioxide gas will be evolved. These papers can then be treated normally with Physical Developer.

The maleic acid pre-wash may cause some damage to certain types of paper and for this reason it may be omitted for fragile papers such as tissue which are unlikely to have a high filler content. Other types of porous surface such as wood contain no alkaline fillers so there is no need to use a maleic acid pre-wash.

Publication No. DSTL/PUB126361

As items are processed, silver is removed from the Physical Developer Working Solution and there is less to deposit on the next items. With every item that is put through the process, the longer it takes to develop fingermarks until the process becomes unacceptably slow. The Physical Developer Working Solution can then be replaced and the item continued being treated until mark-to-background contrast is judged to be optimal.

Publication No. DSTL/PUB126361

CONTACT US

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Note: Dstl's email system does not send out-of-office replies to non-Dstl accounts. To avoid delay to enquiries that are time-critical, please ensure that the central mailbox is used in preference to individual staff mailboxes.

Address

Dstl, Porton Down, Salisbury, Wiltshire, SP4 0JQ, UK

Publications

Fingermark and related forensic documents, including the Source Book v2.0 (second edition), can be found on the following website:
https://www.gov.uk/government/publications/dstl-forensic-publications

These documents were produced by a team of scientists within the Dstl Security Systems Programme. This team integrated into Dstl in April 2018 from the Home Office Centre for Applied Science and Technology (CAST), which was previously known as the Home Office Scientific Development Branch (HOSDB) and Police Scientific Development Branch (PSDB). In order to maintain one single archive for these reference documents, this series of publications includes those produced prior to April 2018.

For sales of the Fingermark Visualisation Manual (FVM) please contact Clare Polley, Official/Library Channel Sales Manager, Williams Lea Tag, WLT:
Clare.Polley@wlt.com.

Home Office Commissioning Hub

This fingermark visualisation research has been funded by the Home Office. If you have a new work requirement that you would like the Dstl team to explore, please contact the Home Office Commissioning Hub, who are responsible for tasking Dstl on behalf of the UK Home Office & Law Enforcement; their email address is:
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